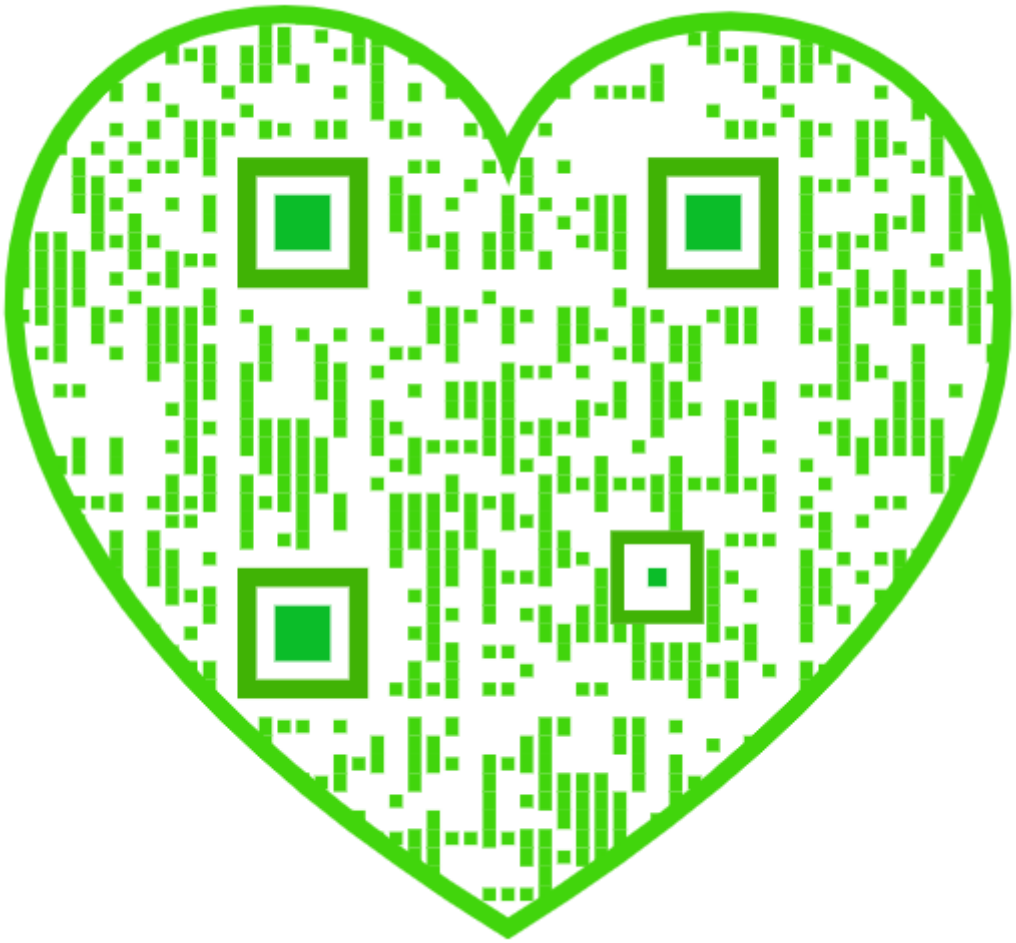
SURGICAL ASEPSIS

BY

HENRY B. PALMER



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SURGICAL ASEPSIS.

PALMER.

SURGICAL ASEPSIS

Especially Adapted to Operations in the Home of the Patient

BY

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WITH NINETY ILLUSTRATIONS

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PREFACE.

THE aims of this book are to demonstrate that surgical work may be safely performed in the home of the patient, and to detail the methods which the writer has found best to secure such a result.

If the home be a good one, and if the same degree of surgical skill and nursing can be secured, the home treatment of surgical cases offers some very decided advantages over the hospital. The home environments, the greater degree of quiet which may be secured, and the knowledge of the patient that he is among his friends and under the care of his family physician are great aids toward securing that quietude of mind which will hasten the recovery.

After convalescence is established the patient is usually anxious to leave the hospital, and often returns to his home sooner than it is advisable that he should travel. Were he operated on at home he would neither be subjected to this risk nor would the convalescence be retarded by his anxiety to return home.

The methods described in this volume embody the principles commonly accepted, modified in the manner found most convenient for house-to-house

operating. It has been written especially for those surgeons who often operate outside of the hospital, and for the general practitioner who may do some surgery or has the after-care of surgical cases.

Only so much of bacteriology and theory have been included as has seemed necessary to the full understanding of the requirements for aseptic work, and to prove the ground taken on some unsettled points.

The author has availed himself of the writers on aseptic technique, and would especially acknowledge the assistance received from the works of Schimmelbusch, Kelly, and Robb.

Farmington, Maine.

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CHAPTER I.

GENERAL CONSIDERATIONS OF ASEPTIC WOUND TREATMENT.

The results which follow the aseptic treatment of wounds have not only made it possible for the general practitioner to undertake surgical work which formerly would have been impracticable for him to do, but they have forced upon him obligations, in sudden emergencies, which he cannot escape.

Moreover, in private surgical practice it is often the family physician who must direct the details of the preparation for the operation, assist in its performance, and carry out the suggestions of the surgeon in the dressing of the wound and the after-care of the patient. He must therefore thoroughly understand the principles and technique of aseptic surgical work, even though he does no operative work.

By an *aseptic* in contradistinction to an *antiseptic* technique we mean one in which every article that comes in contact with the wound has been previously freed from active organisms, and one in which no chemical antiseptics are employed in contact with the wound. On the other hand, the antiseptic technique presupposes a certain amount of contamination of the wound, and attempts to destroy, by chemical substances, the bacteria which have gained access to it.

So long as it was supposed that bacteria gained

entrance to the wound principally through the atmosphere, chemical disinfectants in contact with it were deemed necessary. Now we know that infection nearly always comes from contact, and the exclusion of disease-germs from the wound is more nearly under our control.

The use of chemical disinfectants is necessary in the preparation for an aseptic operation, but the antiseptics are used before the wound is made, and not in contact with it.

The advantage of aseptic wound treatment over the antiseptic is very obvious. The more potent antiseptics—as bichloride of mercury, carbolic acid, and iodoform—may produce serious and even dangerous constitutional effects if used on any extensive wound or absorbing surface. In such strength that they are efficient as germicides they produce cellular necrosis of the tissues on the surface of the wound. Dr. Halsted has shown that the irrigation of fresh wounds with a solution of bichloride of mercury of only the strength of 1 to 10,000 causes a line of superficial necrosis which can be demonstrated under the microscope. This cellular necrosis retards the repair in the wound and lessens the normal resistance of the tissues to the action of any bacteria which may gain access to them, either during or subsequent to the operation.

Antiseptic solutions should never be used in contact with serous membranes, as they favor the formation of adhesions. In the peritoneal cavity and in joints this is especially disastrous.

Accidental wounds are usually already infected. In such a case the wound may be thoroughly

washed with some reliable antiseptic solution and then treated as an aseptic wound.

While the term aseptic would imply that the wound is kept perfectly germ-free, the fact remains that the hands of the surgeon and the skin of the patient cannot be absolutely sterilized by any known method. There are also a small number of bacteria which gain entrance from the air. But the tissues of the body are capable of resisting small numbers of bacteria, so that septic infection and wound suppuration have been almost completely banished from most hospitals and may be avoided in private surgical practice with equal certainty.

There are several factors which determine the existence or non-existence of suppuration in a wound. The principal ones are the number of bacteria present in the wound, the virulence of the organisms, the presence of fluids which may act as culture media for their development, and the resistance of the tissues to the microbic invasion.

Watson Cheyne has shown that the number of bacteria introduced not only modifies the symptoms, but also the character, of the septicæmia. He experimented with a pure culture of the proteus vulgaris injected into the muscular tissue of rabbits. He estimated that $^1/_{10}$ cubic centimeter of a pure culture contained about 225,000,000 bacteria, and he found that this amount caused the speedy death of the rabbit when injected.

A quantity of the same culture representing $^1/_{40}$ cubic centimeter caused only a localized abscess at the point of the injection and the death of the animal in six or eight weeks.

Amounts of less than $^1/_{500}$ cubic centimeter and containing 450,000 bacteria produced no results.

When the various pus-producing organisms gain access to the tissues they may likewise cause simply an inflammation which does not disorganize the tissues and cause suppuration, or if larger numbers are introduced they may cause a localized suppuration, or they may gain access in such numbers as to cause a rapidly fatal result before suppuration has taken place. The healthy tissues can usually resist a certain number of pathogenic organisms of a given virulence, and it is only in a few instances that a very small number will produce a fatal result.

Different varieties of bacteria vary greatly in the number required to produce a fatal result. One or two of the bacilli of anthrax injected into a rabbit will produce a fatal form of the disease, while it requires at least 1000 of the bacilli of tetanus, and more than 18,000 of the proteus vulgaris to produce the same result.

Not only do the different varieties vary in their virulence, but the same organism may vary greatly, according to its source. The pyogenic organisms from an abscess in active development are much more active than are the same organisms from a chronic suppuration. But the virulence of an attenuated organism may be increased by passing through this active change; so that bacteria taken from a chronic source of suppuration may produce only mild infection, while the bacteria taken from this mild, but acute, case may produce a virulent septicæmia. The colon bacillus is much more virulent when taken from a suppurating peritonitis than when taken from its normal habitat in the intestinal canal.

Some organisms also seem capable of attacking only certain kinds of tissue. The gonococcus, which is a very virulent organism in the genital tract and the eye, seems almost incapable of existence in any other tissue unless it may possibly be in the joints.

Intraperitoneal injections of pure cultures of the gonococcus into white mice or guinea-pigs cause a localized inflammation and suppuration, which rapidly subsides and the organisms die out. This shows that, while the organisms in large numbers may produce a certain amount of inflammation, they have little or no power of multiplying or spreading in their tissues. It must be remembered that gonococci are inactive also in the genital tract of all the lower animals; so that these experiments are of less value than they would otherwise be. But clinical experience has shown that the gonococcus has little power of proliferation in the peritoneal cavity of the human subject, and, when this organism alone is found in cases of pyosalpinx, there is little danger of peritonitis.

As has been intimated, a limitation of fluids which may act as culture media lessens the danger of sepsis. For the development of bacteria in a wound it is necessary that there should be both the seed and the soil suitable for its growth.

Serum and blood-clot, when aided by the heat of the body, furnish ideal conditions for the development of bacteria.

Retained fluids in a wound, besides acting as a culture medium, lessen, by their pressure and consequent obstruction of the capillary circulation, the resistance of the adjacent tissues to the action of bac-

teria. Necrosed tissue from the use of clamps, retractors, strong antiseptics, or the cautery also furnishes a good soil.

It is therefore important that clean incisions should be made, and the tissues should be protected from bruising as much as possible.

Blunt dissection should not be employed except when absolutely necessary. All oozing should be checked and the wound be made clean and dry before it is closed. The same objection which has been made to the use of strong antiseptics may be made to the use of very hot compresses or the hot flushing which is so much used to check capillary oozing. These measures cause coagulation necrosis.

Fluid at a temperature higher than 110° to 112° F. is certainly capable of doing much harm in the peritoneal cavity. After its use it may be observed that the serous membrane has lost its luster and it is much more likely to be invaded by any germs which may be present.

The resistance of the tissues to the action of bacteria is a matter of great importance to us. As was shown by Cheyne in the experiments which have been mentioned, a considerable number of bacteria may be destroyed by the tissue-cells. Prof. J. G. Clark in the *Johns Hopkins Bulletin*, April, 1897, gives some very painstaking experiments on the tolerance of the peritoneum to a limited quantity of microorganisms. He also found that the germs are much more readily eliminated by the tissues when they are diluted by sterile fluid which is easily taken up by the lymphatics. This fact, combined with the discovery of Muscatello, that fluids are principally elim-

inated from the peritoneal cavity through the lymph-spaces of the diaphragmatic peritoneum, has led to the postural method of drainage employed by Kelly, of Baltimore, and later by many other surgeons.

This consists in leaving from one to two pints of normal salt solution in the abdominal cavity and the elevation of the foot of the bed eighteen inches. Muscatello found that there is normally a current in the peritoneal cavity which carries fluids and foreign particles toward the diaphragm, regardless of the posture of the animal, although gravity greatly assists or retards this current. In dogs that were suspended with heads down, carmine bodies which had been introduced into the peritoneal cavity appeared in the retrosternal and thoracic lymph-glands in from five to seven minutes, while in animals in which the posture was reversed it was five and one-half hours before they could be recovered in these glands. Wegner also found that the peritoneal cavity of the dog may absorb a remarkable amount of fluid, in some cases amounting to from 3 to 8 per cent. of the bodily weight in one hour.

The tissues dispose of bacteria when encountered in small numbers by the process of phagocytosis. In this process the leucocytes are the most active agents, but the fixed tissue-cells also take a part. The bacterium is enveloped by the cell and is digested by it. Cobbett and Melsome made some interesting observations upon the destruction of bacteria in the peritoneal cavity of rabbits. After injecting 5 cubic centimeters of broth culture which was swimming with streptococci, they killed the animal in thirty hours, and found only one chain of

streptococci, but many single cocci were found enveloped in leucocytes. In other animals treated in the same manner no active streptococci were found. When a larger number of the bacteria are introduced, the leucocytes are unable to cope with the rapidly multiplying germs, and suppuration or septicæmia ensues. Aseptic animal tissue—as catgut or decalcified bone—is removed after the same manner that the bacteria are destroyed.

The general condition of the patient has much to do with the resistance of the tissues to microbic invasion. Especially are the subjects of organic disease of the heart, arterial sclerosis, chronic nephritis, pyelitis, diabetes, and cirrhosis of the liver liable to septic infection. In a recent number of the *Johns Hopkins Bulletin* Dr. Simon Flexner has called special attention to these causes of septic infection under the title of "Terminal Infections."

From the results of Dr. Clark's experiments, which have been referred to, Dr. Howard A. Kelly draws the following conclusions:—

1. Under normal conditions the peritoneum can dispose of large numbers of pyogenic organisms without producing peritonitis.

2. The less the absorptive power of the peritoneum, the greater is the danger of infection.

3. Irritant chemical substances injure the tissues of the peritoneum, and prepare a lodging place for organisms which becomes the starting-point for peritonitis.

4. Stagnation of fluids in dead spaces favors the production of peritonitis by furnishing a suitable culture medium for the growth of bacteria.

5. The association of infectious bacteria with blood-clots in the peritoneal cavity is especially liable to produce peritonitis.

6. Traumatic injury or bruising of tissue are strong etiological factors in the production of sepsis when associated with infectious organisms.

The fact that the tissues are capable of successfully combating a limited number of bacteria should certainly not cause us to relax our vigilance in any way, but it explains why infection does not always follow the entrance of the bacteria which unavoidably gain access to the wound.

CHAPTER II.

PATHOGENIC BACTERIA.

Inflammation in all its forms is the result of the action of one or more kinds of pathogenic bacteria upon the tissues.

Suppuration is caused by the presence of some variety of the pus-producing bacteria in such numbers that the tissues are incapable of their destruction and elimination. When present in small numbers these pyogenic bacteria may give rise to a simple non-suppurative inflammation. When the inflammation follows this fortunate course, the bacteria are destroyed by the leucocytes, which pass through the walls of the capillaries and attack the bacteria. Much of the swelling in the affected part is due to this accumulation of leucocytes in the tissues.

When the bacteria are present in such numbers that the leucocytes cannot destroy them, suppuration ensues.

Pus is a mixture of bacteria, leucocytes, and fixed tissue-cells which have been liquefied by the peptonizing action of the bacteria or of ferments produced by them. In rare cases pus, which is free from active micro-organisms, may be found, the bacteria from some cause having died out after suppuration has occurred. In old cases of pyosalpinx it is not unusual to find the pus sterile.

Suppuration always causes both local and systemic disturbance, but either may predominate to such a degree that the other is overshadowed. Locally, it destroys the fixed tissue-cells. The systemic effects may be caused either by the entrance into the circulation of the bacteria themselves or by the toxins which are formed at the point of suppuration.

Septic Intoxication is the poisoning caused by absorption of the toxins from a localized infection without the entrance of bacteria into the circulation. When this form of infection alone is present, recovery speedily follows the removal of the pus from the local lesion, thus cutting off the supply of the infecting agent.

Bacteræmia is the blood disease caused by the presence and multiplication in the blood of pathogenic bacteria.

Septicæmia is that form of bacteræmia in which pyogenic germs invade the circulatory system from some primary seat of infection, and multiply so rapidly in the blood that the patient usually dies within a few days.

Pyæmia is septicæmia plus secondary abscesses, disseminated from an infected thrombus. It is less acute in its course than septicæmia, principally because those cases which we designate septicæmia are so rapidly fatal that there is no opportunity for localized abscesses to form.

There must be some gateway, or atrium, for the entrance of the germs to the tissues. The unbroken skin is a very effectual barrier to their entrance, but they may penetrate it through a hair-follicle and give rise to furuncle. Another common entrance is

through the gastro-intestinal tract to the general circulation.

Ordinarily, when a small number of bacteria gain entrance to the blood they are destroyed by the tissues without producing symptoms; but any trauma which is sustained may cause a localization of the bacteria at that point by the blood-stasis which the injury causes. It is in this manner that an inflammation is caused by an injury which does not break the skin.

That pus-microbes are the immediate and essential cause of suppurative inflammation and pus-formation has been well established by clinical observation and experimentation. Whenever the surgeon divides the tissues he makes an atrium for the entrance of pathogenic bacteria. It is not intended, here, to go into the bacteriology of wound infection to any great degree, but it is necessary to note the characteristics of some of the more common pathogenic organisms.

PYOGENIC BACTERIA.

Staphylococcus Pyogenes.—There are three varieties of this organism: the staphylococcus pyogenes aureus, albus, and citreus. These are the most common bacteria which are present, either alone or with other varieties, in acute suppuration. Their frequency is in the order in which they are named. These organisms resemble each other very closely in appearance, with the exception of their color. They are spherical cocci growing irregularly in clusters or in masses. In culture media they grow

rapidly at ordinary room temperature, but multiply much more rapidly at the temperature of the body. They have considerable tenacity of life outside the body, and it requires a somewhat higher degree of temperature to destroy them than most other bacteria which are free from spores. They are found almost universally distributed in Nature, being in the soil, on the skin, in water, and, in fact, are usually present on any unsterilized object.

The staphylococcus aureus is the most virulent of these organisms, as well as the most frequently encountered.

Staphylococcus Epidermidis Albus.—Prof. William H. Welch discovered this organism present in the deeper layers of the skin almost constantly, even after the most rigid sterilization. To it he attributes many of the stitch abscesses, although it is very often present in wounds which heal without suppuration. It is the least virulent of all the pyogenic bacteria. In general characteristics it resembles very closely the staphylococcus pyogenes albus, and by many bacteriologists is considered only as a variety of that organism.

Streptococcus Pyogenes. — This is the organism which is usually found in a spreading phlegmonous inflammation. Under the microscope it is seen in chains much like a string of beads. It is not so frequently encountered as are the staphylococci, but it is much more virulent. It causes a rapidly spreading infection, and when present in suppurative peritonitis the peritoneal surface looks blistered and covered with patches resembling wash-leather. When this condition is found the case is always very serious.

FIG. 1.

Staphylococcus pyogenes aureus.

FIG. 2.

Streptococcus pyogenes.

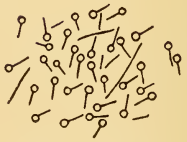
FIG. 3.

Gonococcus.

FIG. 4.

Bacillus coli communis.

FIG. 5.



Bacillus tetani.

FIG. 6.

Bacillus tuberculosis.

Gonococcus of Neisser. — This organism is the specific cause of gonorrhœa, and has an interest to the surgeon principally from being often encountered in operations complicated with tubal disease.

These bacteria are distinguished by occurring in clusters, within pus-corpuscles. They are very virulent when brought in contact with the mucous surfaces of the genito-urinary tract, but are difficult to cultivate outside the body, and have very little virulence when introduced into the peritoneum or connective tissue.

Its virulence is so slight here that Dr. Kelly has abandoned drainage of the abdominal cavity when the microscope reveals only gonococci in the pus which is encountered.

Bacterium Coli Commune.—This bacillus is always present in the intestinal canal. Usually in conjunction with the staphylococcus or streptococcus pyogenes it is present in appendical and ischio-rectal abscesses. It may also appear in organs remote from the intestinal tract. It is a frequent factor in suppurative inflammation of the gall-bladder. It is this organism which gives the characteristic fæcal odor which is commonly observed in appendical abscesses. As the organism is of very slight virulence as compared with the other pus-producing bacteria, this odor is not an unfavorable sign. In shape this bacillus is a rod with rounded ends, sometimes so short as to appear almost spherical and again it may be much longer.

NON-PYOGENIC BACTERIA.

In addition to the bacteria which may produce suppuration in a wound there are many which are capable of producing serious disturbance or a fatal result, even though the wound may heal promptly. These bacteria poison the system principally by the toxins which are formed at the site of the wound and are rapidly taken into the general circulation. Bacteria themselves may also be often demonstrated in the blood and in organs distant from the original entrance of the organisms.

Streptococcus Erysipelatosus. — This organism is the essential cause of erysipelas, which was the bane of the older surgeons. This streptococcus invades the superficial lymphatic channels of the skin exclusively. They appear under the microscope to be identical with the *streptococcus pyogenes*, and are now regarded as being the same by nearly all bacteriologists. From a clinical standpoint there is abundant proof that erysipelas is caused by its own specific organism, which is so nearly identical with the *streptococcus pyogenes* in its staining properties, cultural characteristics, and appearance under the microscope that it cannot be differentiated.

Bacillus Tetani. — This bacillus is not so commonly encountered as most other forms, but owing to its extreme virulence it is of great interest to the surgeon. It is usually found in the soil and in the excreta of the domestic animals. It is anaërobic, or incapable of multiplying in the presence of oxygen.

The bacilli may retain their vitality, however, for several months in the open air and will take on

active development as soon as favorable conditions are presented. They are most likely to develop in accidental punctured wounds of the hands and feet. Wounds in these situations are most likely to come in contact with soil, and punctured wounds which do not allow the entrance of air are favorable for the development of this bacillus.

The bacilli appear under the microscope as slender rods, and at the temperature of the body they multiply by the formation of spores at one end of the rod, giving it the appearance of a pin or drumstick. This property of spore-formation by the bacillus is of practical importance, as the spores are more resistant to the ordinary means of sterilization than are the bacteria. The spores are not destroyed by a temperature of 165° F. in an hour. They will also resist the action of a solution of bichloride of mercury 1 to 1000 for three hours and a 5-per-cent. solution of carbolic acid for ten hours. To insure their destruction by steam sterilization the fractional method should be used. They are destroyed by boiling water in three to five minutes.

Bacillus of Tuberculosis. — This bacillus is the smallest of the bacteria which are pathogenic to man. It is a slender rod which varies in length, being from one-fourth to three-fourths the diameter of a red blood-corpuscle. Under the microscope it is principally distinguished by its peculiar staining properties.

Tubercle bacilli have considerable power of resistance to external influences, and can retain their vitality outside the body for a long time. Dried

sputum has been found to contain active bacilli after two months.

From the prevalence of pulmonary tuberculosis and the usual carelessness in the disposal of sputa, the germs must be widely distributed.

We would expect that wounds would be more commonly infected by this organism than we find them to be.

The tissues of most healthy persons are resistant to these germs, and Volkmann stated, several years ago, that tubercular infection never follows any extensive trauma, but often does follow slight injuries or contusions. He explained this by assuming that the active tissue changes which accompany any severe traumatism prevents the infection. Since the phagocytic action of the leucocytes has been demonstrated, this action can be easily understood. It is probably by this determination of leucocytes to the seat of injury that cases of tubercular peritonitis are cured by simply opening the abdomen.

The bacilli develop, under certain conditions, by the formation of spores, and these resist the ordinary method of sterilization and require the fractional method. The bacillus of tuberculosis is not a pus-producing organism, and the contents of a tubercular, or cold, abscess is not true pus unless accidentally infected by some of the pyogenic bacteria.

These tubercular abscesses, to prevent secondary infection, should be opened under aseptic precautions.

There are several other pathogenic organisms by which wounds are sometimes infected, but these already mentioned are the more common ones, and

the same means which are employed for their destruction will destroy all others.

Many varieties of bacteria, which may be demonstrated under the microscope, are harmless to the human organism.

CHAPTER III.

SOURCES OF INFECTION.

In the avoidance of infection it is necessary to know every avenue by which bacteria may gain entrance to the wound.

The ways in which they may do this are by the air, the hands of the surgeon or skin of the patient, the surgeon's instruments, by the fluids introduced into the wound, by sponges, by sutures and ligatures, and by the dressings.

This statement presupposes a wound through healthy tissues. The wound may be infected by any of the pathogenic organisms which are already present in the tissues.

Air Infection.—It was formerly supposed that the principal source of wound infection was by air contamination, and it was against this source of infection that Listerism was directed. It has been found that the air contains very few micro-organisms, and that these are almost entirely associated with the dry dust floating in it.

The essential conditions for the growth of bacteria—warmth, moisture, and a nutrient medium—are not present in the atmosphere. Only transitorily and in comparatively small numbers do they gain access to it from the warm, moist, and organic material of the earth's surface. Stern has shown that, after the artificial dissemination of bacteria in the air of a

room, they gravitate to the surface by their weight, and that in half an hour the air is practically germ-free. They can float in the atmosphere only in a dry state, and cannot rise from a moist surface. Any liquid which is loaded with bacteria and even fœtid from the products of decomposition cannot give off any bacteria to the air. Only the gaseous products of bacterial action can arise from a moist surface.

Tyndall discovered several years ago (and it has since been confirmed by numerous bacteriologists) that the breath is entirely free from germs. This must be qualified by the statement that particles of mucus or other solid matter which may be carried with the breath may carry bacteria. In a clean room, which is free from dust, air infection may be entirely ignored. It has been estimated that there are more than a thousand times as many germs in a single drop of pus than are ordinarily present in a cubic yard of the atmosphere.

Water Infection.—Almost every wound, whether accidental or made by design of the surgeon, comes in contact with water. If it is accidental, it is "cleansed" by the patient or his friends. When made by the surgeon it is sponged or irrigated. It, therefore, is of great interest to us to know what organisms water may contain.

Bacteria are always present in water from all sources. Even rain-water is not germ-free, as it collects a certain number, in its descent, from the dust floating in the air.

Water which contains organic material is an ideal culture medium for bacteria, especially if the temperature is favorable. It is the collection of bac-

teria which causes the greenish collection on the surface of stagnant pools, and the slimy deposit on the sides of vessels in which water has been left standing for some time.

In addition to being a good culture medium, in the course of its percolation through the soil it gathers some of the bacteria which are always abundant in the earth.

Water, in most of our large cities, is taken from some large river which is a receptacle for numberless millions of bacteria from the drainage of other towns on its banks. Even if the original supply is reasonably pure, the water is usually stored in a reservoir, in which all the conditions favorable for the development of bacteria are present.

In country places the supply is most often from a well. This is usually situated in close proximity to the dwelling and also often near the stable. Very few wells in the country are free from contamination by drainage from the soil.

The investigations at the Hygienic Institute of Berlin estimated that the water of the river Spree contained an average of 37,525 bacteria per cubic centimeter, giving an average of 2500 to every drop of water. When we consider that the air of the hospitals, situated upon the bank of that river, according to the estimate of the same observers, contains only about 3000 bacteria per cubic meter, the comparison between air and water infection becomes very marked. According to these estimates, a cubic meter of this water would contain about 12,500,000 times as many bacteria as would the same volume of air.

Infection by Contact. — In the pre-antiseptic period the most common carriers of infection were the hands or instruments of the surgeon, the sponges, and the dressings. So long as suppuration and its frequently resulting septicæmia or pyæmia were encountered, they were considered to be the legitimate results of any wound, as suppuration was supposed to be the natural method for the repair of wounds. But occasionally an epidemic of erysipelas or gangrene of such magnitude as to require the closing of the hospital would occur. These epidemics were supposed to arise from the vitiated air of the hospital. Such was not the case, but the germs of infection were carried from patient to patient by the unsterilized instruments or by the hands of the surgeon or his dresser.

Instruments which are incapable of being perfectly cleansed of blood or shreds of tissue are excellent harbors for the lodgment and multiplication of germs.

The hands of the surgeon and the skin of the patient are constantly the habitat of a number of varieties of bacteria, and especially of those which produce suppuration.

The ordinary unsterilized gauze or cotton dressing contains many bacteria, and even the commonly used iodoform gauze is not free from them. Ligatures and sutures are important as carriers of infection. They are buried in the depths of the wound, and any bacteria which they carry in their meshes find conditions favorable for a rapid development. All kinds of sutures and ligatures may be readily sterilized except the absorbable ones.

Until very recently no method had been found by which these could be sterilized with certainty without disintegration of the ligatures. Being of organic material, they furnished an excellent pabulum for the support of bacteria. At the present time methods are so well perfected for the sterilization and preservation of absorbable sutures and ligatures that they may be used with perfect safety.

CHAPTER IV.

MEANS OF STERILIZATION.

By sterilization we mean the process of rendering an object completely free from living organisms. Means which we may adopt with advantage for the sterilization of some articles are unsuitable for others. According to the individual conditions, one sterilizing procedure is to be preferred at one time, and some other at another time.

Very frequently a single method of sterilization does not suffice, and we are required to use several together or in succession. In the selection of the method of disinfection we must consider:—

1. The composition of the object to be disinfected and its liability to injury by the disinfecting agent.

2. The resistance of the organisms to be destroyed.

3. The disinfecting power of the agent to be applied.

4. The resistance which may be opposed to the disinfecting agent by the form of the object, by layers of fat or dirt which may envelop it, or by chemical changes which its contact with the disinfectant will cause.

The means at our disposal for the removal of bacteria are:—

1. Mechanical removal by washing and scrubbing.
2. Destruction by heat.
3. Destruction by chemical germicides.

Of these means, the first mentioned easily stands first in importance, and some eminent surgeons, including Lawson Tait, claim to use no further means of disinfection. It occurs, however, that Tait washed his own hands and the field of operation with oil of turpentine, which is a most excellent germicide.

WASHING AND SCRUBBING.

Simple cleansing is the preparatory step in every disinfection, and scrupulous cleanliness in surgical practice is our most important resource in the avoidance of infection. Everything which can be washed should be made scrupulously clean by soap and water. Especially does this apply to the hands of the surgeon, the field of operation, all instruments, trays, basins, pitchers, operating gowns, etc.

In this process of scrubbing soap plays an important part by softening the epidermis and dissolving the fats. One should be selected which contains enough alkali to dissolve the fats from the skin. This solvent action may be increased by the addition of alcohol or ether to the soap.

Ordinary soaps are not germicidal, but in strong solutions they inhibit the multiplication of bacteria. Some soaps are made germicidal by the addition of antiseptics.

Tincture of green soap is usually advised for skin disinfection, and it may well be relied upon. It

is a strong potash soap with about 30 per cent. of alcohol added.

The ethereal antiseptic soap made by Parke, Davis & Co. is especially adapted to the cleansing of the skin, as the ether dissolves the fat from the cuticle and allows the chemical disinfectants which follow to penetrate more deeply.

Among the germicidal soaps, synol, made by Johnson & Johnson; and McClintock's germicidal soap, made by Parke, Davis & Co., are the most reliable. Their value, as germicides, has been demonstrated in 1- and 2-per-cent. solutions. In actual use, the strength of solution in which the soap will be used will be very indefinite.

Synol is claimed by its makers to depend for its germicidal action upon the cresol bases, combined with a pure alkaline soap. It has been tested both clinically and in the laboratory by Dr. A. H. Goelet, of New York, and he uses no other means of skin disinfection. He has found that, after five minutes' scrubbing by nail brush, with synol, the scrapings from the hands show them to be free from germs.

McClintock's germicidal soap is intended rather as a germicide than as a soap, but is put up in cakes for convenience and for the auxiliary effect of the saponaceous material upon the mercuric salt which it contains. The soap contains 2 per cent. of mercuric iodide, and a 1-per-cent. solution of the soap would contain iodide of mercury in the strength of 1 to 5000.

Dr. McClintock claims that a 1-per-cent. solution of this soap is equivalent in germicidal power to a solution of bichloride of mercury of a strength of

1 to 1000. This soap has no corrosive action on metals and does not coagulate albumin. The author has used this preparation and has been well satisfied with clinical results. If used repeatedly, it is quite irritating to the skin of some persons. Were it not for this objection it would be a valuable addition to the resources of the surgeon.

In routine work, disinfecting the skin by simple scrubbing with soap and water, to be *followed* by some reliable antiseptic, is to be preferred to the combination of antiseptics with the soap.

In emergency cases, or where an elaborate technique is impossible, the germicidal soaps may be used.

HEAT.

Heat, in the various ways we employ it, is the most certainly destructive to germs of any means at our command. This method of sterilization should be applied to every object which is not injured by its action. The methods of using heat as a disinfectant are the actual flame, dry heat, steam, and boiling water.

The flame is very seldom used for sterilization, but, if other means are not at hand, it may be used for the disinfection of probes, needles of hypodermic syringes, and other small instruments. It draws the temper of steel instruments.

Dry heat is not so efficient as is steam for sterilization, and it requires special apparatus for its use. It is seldom used as a disinfectant, and it would better be discarded altogether. It requires an exposure of one hour and a half, at 212° F., of dry heat to destroy

the pyogenic bacteria, while they are destroyed in twenty minutes by steam at the same temperature.

Boiling water is the most potent of any form of heat and should always be used when possible. Ordinary bacteria are destroyed by boiling water in from three to five seconds, and anthrax spores, which are the most virulent in form, in about two minutes. Boiling water may be used for the sterilization of nearly all instruments, small basins, silk, silk-worm, or silver sutures, and when a sterilizer is not at hand gauze sponges may be disinfected by boiling.

Steam, at a temperature of 212° F., is equally as effective as boiling water for the destruction of germs, although it does not act as rapidly. When used under pressure, the temperature may be raised much above the boiling point of water and its germicidal action is greatly hastened. It has also been found that most organisms, which do not contain spores, can be destroyed by a prolonged exposure to steam much below the boiling point of water. A temperature of 145° F. is sufficient to kill most bacteria in two hours, according to Pasteur and Tyndall.

Steam, at 212° F., is destructive to all ordinary bacteria in fifteen or twenty minutes, if they are freely exposed to its action. It is also necessary that the steam should be saturated; that is, unmixed with air.

Much has been said about the relative value of live steam, or steam in circulation, and steam at rest. One is as effectual as the other when it comes in contact with the bacteria, but live steam penetrates packages much more quickly and so lessens the time required for the process.

For the effective use of steam, as a sterilizing agent, it is desirable to have an apparatus which will force a good volume of live steam into the sterilizing chamber, and that the temperature in this chamber

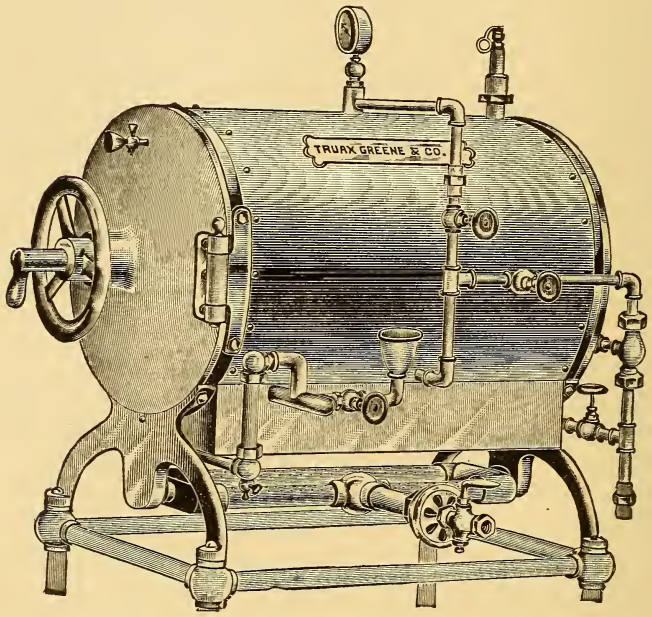


Fig. 7.—High-Pressure Steam Sterilizer Manufactured by Truax, Greene & Co.

should be maintained at a temperature of at least 212° F.

There are three classes of sterilizers: The high pressure, the understeam, and the oversteam. The high-pressure sterilizers are not portable and are expensive; so they are used only in hospitals and pri-

vate operating rooms. Truax, Greene & Co., of Chicago, and the Kny-Scheerer Company, of New York, make some very elaborate sterilizers of this variety. With these instruments at a temperature of 230° F. and a pressure of 5 pounds to the square inch all the pathogenic bacteria excepting those which carry spores may be destroyed with certainty in five minutes.

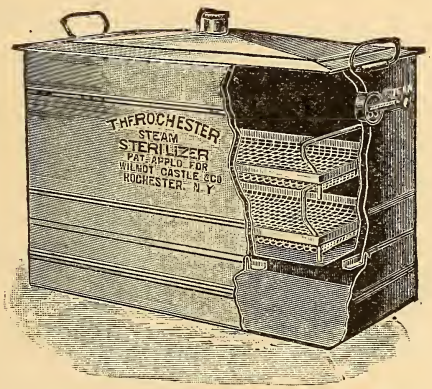


Fig. 8.—Sectional View of Arnold Sterilizer.

The understeam and oversteam sterilizers are intended to maintain a temperature of 212° F., and must be so constructed that a good volume of steam is constantly forced into the sterilizing chamber under moderate pressure, and this chamber must be surrounded by a jacket to prevent cooling and condensation at its sides.

The understeam sterilizers are so constructed that the current of steam enters the sterilizing cham-

ber at the bottom, passes upward through or around the articles to be sterilized, and escapes at the top. As air has a higher specific gravity than steam, it is difficult to force it from an understeam sterilizer. The steam as fast as generated passes upward through the overlying air, carrying only a small portion with it as it escapes at the top. The air, being

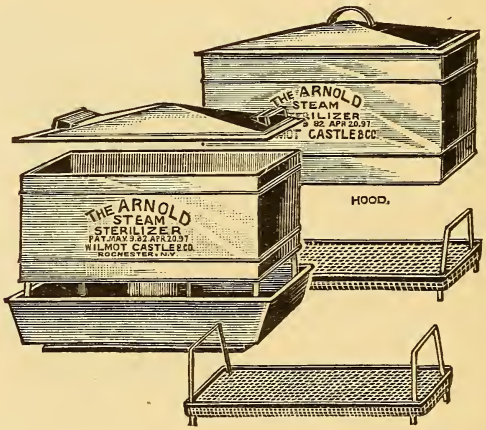


Fig. 9.—View of Parts of Arnold Sterilizer.

heavier, naturally seeks a lower level, and results in an admixture of the two, the upper portion being principally steam, while the lower portion is principally heated air, carrying very little moisture and consequently of much less germicidal power. After a time the air is nearly all expelled from the sterilizing chamber, but the period of exposure must be extended to allow for this, and if any understeam

sterilizer is used the sterilization should be not less than forty-five minutes. The best known of the understeam sterilizers is the Arnold, made by Wilmot Castle & Co., of Rochester, N. Y. It has a device by which only a small amount of water passes from a reservoir into a shallow compartment underneath, to which heat is applied.

As there is only a small amount of water to boil at a time, it is converted into steam very rapidly and

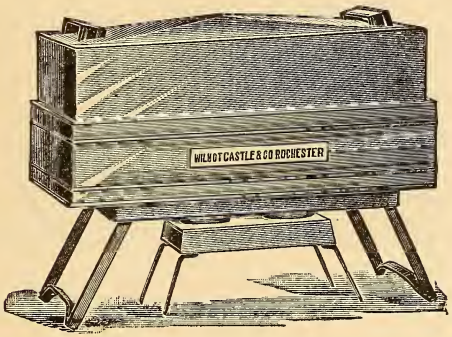


Fig. 10.—Collapsing Sterilizer Ready for Use.

rises through a funnel, in the center, into the sterilizing chamber above. The excess of steam escapes about the cover and forms a steam jacket under the hood, which envelops the sterilizing chamber.

The objections to this sterilizer are that it is unwieldy and noisy to carry about, the solder about the boiling chamber is liable to melt out even with great care, and it is very difficult to repair.

The first of these objections has been overcome, to some extent, by making the sterilizer of a rectan-

gular shape, so that it may be carried in a suitable carrying case.

The Wilmot Castle Company also make a collapsing sterilizer, intended for physicians who operate in private houses. It is very compact, and may be carried in an extension case which is made for it. This sterilizer is so small that it must be filled several times to sterilize all the articles necessary for a major operation. It has no jacket surrounding the sterilizing chamber, so the temperature maintained is somewhat below 212° F., and the period of sterilization must be lengthened to at least an hour.

Fig. 11.—Collapsing Sterilizer Closed.

Oversteam sterilizers are so constructed that the steam current enters the sterilizing chamber at or near the top, and escapes wholly or in great part through openings near the bottom. As steam is lighter than air it collects in the upper portion of the chamber, and can find means for escape only by forcing the air downward and out of the sterilizing chamber. The pressure required to force the air from the sterilizer insures the penetration by steam of the articles to be sterilized, regardless of the manner of wrapping or packing.

One of the best types of oversteam sterilizers

is the Boeckmann (Fig. 35). It consists of two cylinders; the inner one, which constitutes the sterilizing chamber, is inverted, while the outer one, which is about an inch larger in diameter, covers the first, acting as a hood. The steam enters the space between the two cylinders and can enter the inner cylinder only at the top, and escapes through an opening at the bottom.

I have had made for myself a very simple, roomy, and cheap sterilizer for office use. It is made of galvanized iron, but can be made of tin or copper. It consists, first, of a simple box, 16 by 16 by 20 inches in size. This box is provided with a well-fitting cover. Inside this is another box, 14 by 14 by 18 inches in size. This is also supplied with a closely-fitting cover. The bottom of this box is placed about 3 inches above its base, and the corners are clipped from the sheet of iron which forms this partition, so that it forms an opening at each corner of the box through which steam may enter the sterilizing chamber. This is carried nearly to the top of the chamber by soldering a strip of metal into the angle of the box in such a manner that it makes a flue to conduct the steam. It escapes principally through some openings near the base of the sterilizing chamber.

When in use the outer box is filled with water to the depth of one or two inches, and then the inner box is placed within it. All the steam which is generated inside the base of the inner box, or from a surface 14 by 18 inches in area, must pass through the sterilizing chamber and it then escapes through openings near the base, into the outer box. This

insures a good supply of live steam constantly in the sterilizing chamber, and the steam escaping from the inner box fills the space between this and the outer box, and maintains the heat at 212° F.

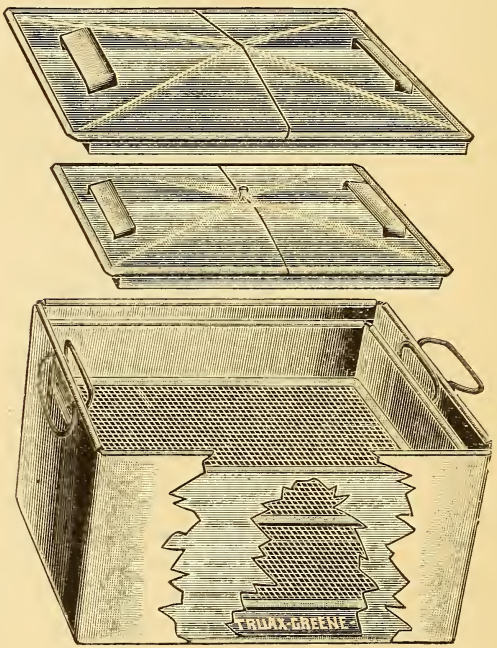


Fig. 12.—Author's Sterilizer.

The only possible objection which can be made to this sterilizer is that it has no double bottom for the rapid generation of steam. This is nearly compensated for by the very large heating surface, and if it is filled with hot water there is very little delay.

The extreme simplicity of the apparatus and the ease with which it may be repaired, if it should boil dry, are points in its favor. It is not easily portable, although one of moderate size might be carried in an extension case.

At times an operation must be performed when it is impossible to secure a sterilizer. Then an ordinary steam cooker may be used, or a wash-boiler with a few inches of water at the bottom and the packages lying upon a clean board supported above the water by two bricks. It is safe to assume that a temperature of 160° F. may be secured in this way, and according to the statements of Pasteur and Tyndall, already cited, this temperature is sufficient to destroy germs, but the sterilization must be continued for one and one-half to two hours.

As has been already stated, a temperature of 212° F. is destructive to all active or vegetative forms of bacteria in from fifteen to twenty minutes. But when dressings, towels, etc., are rolled in packages, this temperature is not reached in the deeper parts of the package for several minutes. Therefore the packages should remain in the sterilizer for at least forty-five minutes.

If the packages are thoroughly warmed before being put in the sterilizer, the steam will not condense upon their surfaces and wet the packages. When removed from the sterilizer they will dry at ordinary room temperature if this precaution has been taken.

Spore-forming bacteria will resist the action of steam, for a long time, at a temperature of 212° F. Most of the spore-forming bacteria are non-pathog-

enic, but those of tetanus and tuberculosis are notable exceptions.

All spore-forming bacteria may be destroyed with certainty by the fractional method of sterilization. By this method the material to be sterilized is exposed to the action of steam for an hour each day, for two or three consecutive days. The active or vegetative germs are destroyed at the first exposure. The spores, which are only larval forms of the bacteria, are developed by the heat into the active form and will be destroyed by the subsequent exposures.

This fractional method of sterilization is often impossible in private surgical practice, but when possible it should be used for all material which is to be left permanently in the wound. Silk, which is to be used for ligatures or buried sutures, gauze for drains, etc., may be kept sterilized, and then again sterilized with the dressings at the time of operation.

Formerly, it was believed that cold was destructive to bacteria, and especially was ice supposed to be free from germs. Most bacteria cannot multiply excepting at a temperature above 60° or 65° F., but even extreme cold is not destructive to them, and they take on an active form as soon as favorable conditions are restored. MacFadyen reports, in the London *Lancet*, March 24, 1900, that he tested ten organisms, including those of typhoid, diphtheria, cholera, and the bacillus coli commune and staphylococcus aureus. He exposed them to liquid air at a temperature of — 360° F. These organisms retained their characteristics, and those that were virulent before were quite as virulent afterward.

CHEMICAL DISINFECTANTS.

Since the introduction of carbolic acid as a germicide, by Lister, chemical disinfection has been constantly used in surgical practice. Various chemicals have been regarded as certainly destructive to all germ-life, and, in the absence of any reliable criteria to demonstrate their efficiency, too much reliance has been placed on this method of disinfection.

Germs which are present in dirt or enveloped in fat are almost entirely protected from the action of germicides in aqueous solution.

Koch demonstrated that the strongest antiseptics dissolved in oil are ineffectual for the destruction of germs in a moist state, because the oil does not penetrate the organisms. Conversely, silk threads impregnated with pus-germs and then immersed in oil may be laid for weeks in a watery solution of mercuric chloride or of carbolic acid without destroying the germs. Especially upon the surface of the body and mucous membranes are the organisms protected by layers of fat; so that mechanical cleansing and the use of solvents for this fat is an important preliminary measure to precede the chemical disinfection.

None of the chemical antiseptics are capable of instantly destroying bacteria, but must remain in contact with them for some time.

Some of the agents, which we have implicitly trusted for years, do not kill the germs even after prolonged contact, but merely inhibit their action. This is especially true of iodoform.

Geppert has demonstrated that our most com-

monly used chemical disinfectant, bichloride of mercury, in solution of 1 to 1000 does not destroy the staphylococcus pyogenes with certainty in ten or even in fifteen minutes.

For the sterilization of objects, which from their size or shape it is impossible to subject to the action of heat, or from their structure would be injured or destroyed by its action, it is necessary to make use of chemical disinfectants. They should be regarded as supplemental, rather than as the principal agents at our disposal.

The ideal chemical disinfectant would be one that might be used for a variety of purposes, readily soluble in water, active in germicidal properties, not decomposed by contact with organic matter, inexpensive, and free from very objectionable odor. One possessing all these properties we do not have.

Of the many chemical substances, which in various degrees are destructive or inhibitory to the action of germs, only a few need be considered in detail.

It is better to employ a few antiseptics, which have been demonstrated by bacteriological experiments to be efficient, rather than to make clinical experiments in the use of new preparations at the peril of the patient.

Some of the chemicals here mentioned are not recommended, but are considered because they are very generally used, and their antiseptic power is assumed and not proven. These chemicals should not be used to the exclusion of those which have been demonstrated to be effective germicides, un-

less from the nature of the tissues they would be injured by the stronger antiseptics.

Bichloride of Mercury combines more of the qualities of an ideal disinfectant than any other chemical. It is colorless, odorless, does not injure any fabric or material, under most circumstances it is a reliable germicide, and it is inexpensive. On account of its corrosive action upon metals it cannot be used for the disinfection of instruments or tin basins. Granite ironware is not injured by it. Its power as a germicide has, however, been greatly overestimated. Its reputation as an antiseptic was due, in great part, to the original investigations of Koch. He asserted that a single application of it for but a few minutes, without any previous preparation of the objects to be disinfected, guaranteed an absolute disinfection, even in the presence of the most resistant organisms.

Geppert first showed the error made in these early experiments, and he has been followed by Abbott, Prudden, and many others. It is now well settled that bichloride solution of the strength of 1 in 1000 does not always kill pathogenic bacteria in ten or fifteen minutes, and that it takes twenty-four hours for a solution of the same strength to kill anthrax spores.

The solution has no action upon fats, and cannot come in contact with germs which are in the deeper layers of the skin and are enveloped in the products of the sweat-glands.

A solution of the strength of 1 to 1000 is the standard solution to be used in the disinfection of basins, tables, and hands. The skin of some per-

sons is susceptible to the action of the solution of this strength, and then it may be used in solution of 1 to 2000.

The period of immersion must be proportionately increased if this strength is used. In the presence of albuminous substances bichloride of mercury is decomposed and forms the inert albuminate of mercury, and the antiseptic power of the solution is diminished in proportion to the amount of these substances present. A solution which contains much blood is almost entirely inert.

Oxycyanide of Mercury, according to the experiments of Deguy (*Journal des Praticiens,* November 3, 1900), has the same germicidal power as the bichloride, and may be used in solutions of the same strength, as a substitute for the latter salt. If other observations should confirm his statement it would be a valuable substitute, as it does not corrode metal instruments and is not so irritating to the skin as is the bichloride.

Carbolic Acid is a mild escharotic, disinfectant, and deodorizer.

It is soluble in water up to 5 per cent., and it is usually used in this strength as a disinfectant in surgical practice. A 5-per-cent. solution is much less active as a germicide than is a 1 to 1000 solution of bichloride of mercury. It requires about five days for the former to destroy anthrax spores, while the latter is destructive to them in twenty-four hours. For ordinary pus-producing bacteria, an exposure of at least two or three hours to a 5-per-cent. solution is necessary to insure their destruction.

About the only use for carbolic acid, in aseptic

surgical work, is for the disinfection of cutting instruments, the temper of which is injured by repeated sterilization by heat, and which are corroded by mercuric solutions. That the sterilization may be certain the instruments must remain in the solution at least three hours; so other means are preferable to this.

Dr. Seneca Powell discovered that the escharotic action of carbolic acid could be prevented by the immediate application of alcohol. The germicidal power of each of these antiseptics is lessened by the association. Dr. Powell often proves to his class the antidotal power of alcohol by bathing his hands first with 95-per-cent. carbolic acid and then with alcohol.

A limited pus-cavity may often be disinfected by this means. The cavity should first be thoroughly washed, then dried by dry sponging. Carbolic acid of a strength of 95 per cent. may be applied to every part of the surface and followed by alcohol. Phelps, of New York, reports excellent success from the treatment of suppurating joints after this plan.

The treatment of infected wounds and suppurating joints by pure carbolic acid and alcohol, after the method of Powell and Phelps, was discussed at the Congress of the German Surgical Association held at Berlin in April, 1901. Professors Bruns and Honsell, of Tübingen, stated that by numerous experiments they had proven that its bactericidal action, when dealing with tissues containing albumin, is greater than that of solutions of mercuric chloride.

Dilute solutions of carbolic acid when applied for several hours may produce gangrene and slough-

ing of the tissues. This is especially true when applied to the extremities.

Dr. F. B. Harrington, of Boston, has collected one hundred and thirty-two cases of gangrene from application of dilute solutions of carbolic acid. His statement, that the condition is probably much more frequent than these figures would indicate, is true. The author has seen gangrene of the finger, in two instances, from application of 5-per-cent. solution of carbolic acid to a small wound.

Alcohol has been regarded as an efficient germicide, and has been extensively used in the disinfection of the skin. Geppert found that anthrax spores resist its action for at least thirty days. It inhibits the action of ordinary bacteria, but it is not destructive to them except upon prolonged contact. Its chief value in skin disinfection is in removing the fat, so that the after-coming antiseptics may be more effective. It should, therefore, *precede* the use of the antiseptics, and should rank as does soap and water: a mechanical aid in the process of disinfection. It is usually employed for the disinfection of knives, but other methods are more reliable.

Potassium Permanganate is an excellent germicide. It acts by the oxidation of organic matter and can attack bacteria when other watery solutions do not reach them.

While having very little odor of itself, it is a most powerful deodorizer. Its oxidizing power is so great that a marine sponge, if left in a saturated solution for half an hour, is almost completely destroyed. It leaves a deep mahogany stain, and cannot be generally used on that account. This stain is

completely removed in a short time by the action of a saturated solution of oxalic acid.

The use of permanganate of potassium is almost entirely in the disinfection of the skin. It is admirably adapted to this, as it oxidizes all the organic matter which cannot be reached by scrubbing or by the use of other aqueous solutions. It should be used in a saturated solution, which is about 1 to 16.

Oxalic Acid is used for the bleaching of the skin after the use of potassium permanganate. Dr. Mary Sherwood has found, by various experiments, that it has a very marked germicidal power of its own.

The slight effervescence which comes from its chemical union with the potassium permanganate carries the chemicals deeply into the skin and generates considerable heat. It is soluble in about 9 parts of water and may be used in solutions varying from 8 to 10 per cent.

Chlorine is a strong germicide, ranking, according to Schimmelbusch, among the first class. Some surgeons use it for skin disinfection. It is obtained by mixing equal parts of commercial chloride of lime and sodium carbonate. This is sufficiently moistened to make a smooth paste, and is thoroughly rubbed over the surface to be disinfected. The germicidal effect is from the chlorine gas which is set free. It has a very penetrating and disagreeable odor, which may be removed from the hands by a dilute solution of ammonia water.

Formaldehyde is one of the newer antiseptics which has stood the tests of both laboratory experiments and clinical experience. Formaldehyde is a pungent gas, obtained by the oxidation of wood

alcohol. It is soluble in water, and a 40-per-cent. solution is sold under the name of formalin, and this is the preparation now most used. It also may be obtained in solid form as paraldehyde.

The gas is non-toxic and is not corrosive to metals. For the gaseous disinfection of rooms it is the most effective agent that we possess. As a result, in great part, of the experiments of Prof. F. C. Robinson, of Bowdoin College, it has superseded nearly all the other methods of room disinfection after contagious diseases. His experiments show that bacteria, which are not more resistant than the bacilli of diphtheria and colon, are destroyed by the vaporization of 500 grammes (about 16 ounces) of formalin to each 1000 cubic feet of room space. Tubercle bacilli were not destroyed with certainty by these means.

Drs. Reik and Watson, of Baltimore, have concluded from their experiments that metallic instruments may be rendered sterile by immersion in a solution of a strength of 1 to 2000 for thirty-five minutes. As the solution is neither corrosive to instruments nor irritating to the skin when used in any strength, it would seem better to use the stronger solutions, from 10 per cent. to 40 per cent., and thus shorten the period required for the disinfection.

For the disinfection of instruments in general, boiling water leaves nothing to be desired, but the formalin disinfection may be used to advantage for the sterilization of those articles which are injured by boiling, as cutting instruments, catheters, etc. It is especially urged that it should supersede alcohol for this purpose.

Lysol is one of the coal tar products, and contains about 50 per cent. of the cresols. It is miscible with water, forming a clear, saponaceous mixture. It may be used in 1- to 2-per-cent. solution. According to Coblentz, a 1-per-cent. solution of lysol is equal in antiseptic power to a 5-per-cent. solution of carbolic acid. According to experiments made at the Boston City Hospital, it requires from 20 to 30 minutes for pure lysol to destroy germs. It therefore should not be classed as a germicide to be used in any aseptic preparation, unless as a mild antiseptic upon mucous surfaces that would be injured by the corrosive disinfectants. For this purpose it is preferable to carbolic acid.

Iodoform is extensively used on wound surfaces and is generally regarded as a germicide. It is possible for germs to live in contact with it, but they cannot multiply. It should not be used unless upon suppurating wounds. If freely used it may cause serious symptoms of poisoning. These symptoms are characterized by rapid pulse and active delirium.

Iodoform appears to have a distinctive action upon the bacilli of tuberculosis in the tissues. Whether this is because the bacilli are especially susceptible to the iodoform or whether active tissue changes, which destroy the germs, are caused by the drug, it is impossible to say.

Aristol is superior to iodoform as a disinfectant except where the tubercle bacilli are the infecting agents. It is non-toxic, is free from objectionable odor, and has no tendency to grow lumpy.

Peroxide of Hydrogen has considerable germicidal power, from the oxygen liberated when it comes in

contact with pus. Its value is enhanced by its mechanical action from the liberation of gas, thus throwing the pus out from hidden pockets and deep sinuses. It is especially efficient in freeing the hands from putrefactive odors after septic cases.

Honsell states that a 3-per-cent. solution is equal in germicidal power to a 1 to 1000 solution of bichloride of mercury.

CHAPTER V.

PRACTICAL APPLICATION OF THE PRINCIPLES OF STERILIZATION.

No SET rules can be laid down for the preparations for an aseptic operation. Every individual surgeon will work out a way in which he can best accomplish the end, and he will often find it convenient to change his usual routine, according to the time at his disposal and the material to be obtained. This may be done with safety if he will but keep constantly in mind the general principles of sterilization.

Skin Disinfection. — Everything connected with any surgical operation may be rendered absolutely free from living germs except the hands of the operator and his assistants and the field of operation. The skin furnishes all the requisites for the lodgment and propagation of germs. It has an equable temperature, the secretion of the cutaneous glands provides the necessary moisture, and the animal and vegetable substances furnish an excellent culture medium. As might be expected, the surface of the body swarms with bacteria of the most varied species. Especially is this true in respect to the hands of the surgeon, as they are repeatedly in contact with diseased tissues and infected wounds.

The surface of the skin may be freed from germs, but the deeper layers always harbor some

organisms, and these gradually find their way to the surface during the operation. In the application of the principles of disinfection to the skin, the mechanical cleansing is of the utmost importance. The inefficiency of the chemical antiseptics has shown the necessity of the thorough removal of the bac-

Fig. 13.—Nail Cleaner.

teria from the surface of the skin by scrubbing and washing.

This mechanical cleansing of the skin is the preliminary to all methods of skin disinfection and should be very thorough and painstaking. The nails should be short and freed as much as possible from dirt by means of the nail cleaner. The hands and

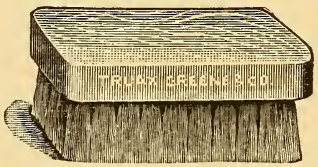


Fig. 14.—Cheap Nail Brush.

forearms should then be washed for several minutes with soap and water as hot as can be comfortably borne. During this process the water should be changed several times, and the nail brush should be used on the hands and especially about the knuckles and nails.

No definite rule can be laid down for the length

of time this scrubbing should continue, as its efficiency will depend much upon the dexterity of the individual and the condition of his skin. A thick, rough or cracked skin furnishes hiding places for germs, from which they are dislodged with considerable difficulty.

The minimum time for which this scrubbing should continue may be placed at five minutes, and Robb found that cultures taken from the hands after scrubbing for ten minutes always showed less bacteria than those taken after only five minutes' work had been done.

The soap to be used for the scrubbing should be strongly alkaline and should also contain alcohol or ether. The free alkali softens the epidermis and loosens the epithelial scales, while the alcohol or ether dissolves the fat from the skin and allows the after-coming chemical disinfectants to extend more deeply.

The tincture of green soap and Johnston's ethereal antiseptic soap answer these requirements. Of late several brands of soap have been offered in which some germicide is incorporated. Of these, the most reliable are McClintock's germicidal soap and synol.

The germicidal soap carries a definite quantity of biniodide of mercury, and a 1-per-cent. solution of the soap makes a 1 to 5000 solution of the mercuric iodide. This has been proven to be an efficient germicide.

Synol contains a fixed, but unpublished, amount of the cresol bases as its germicidal agent, and the cresols, of which lysol is the best exponent, have

been shown to be slow in germicidal action. Yet Dr. Goelet, from an extended use and from laboratory experiments by scrapings from the skin, is satisfied that this is a reliable germicide and employs no other method of skin disinfection.

Both these preparations, even if their germicidal properties are proven, have the disadvantage of being unknown to us as to the exact strength of the solution.

Until further use and experiment have proven their reliability, chemical disinfection should follow the cleansing by soap and water, and should not be combined with it.

Various methods of skin disinfection are regarded as efficient. Probably the most generally used is that originated by Fürbringer. The surface is thoroughly scrubbed with green soap and water, then for one minute with alcohol, and finally soaked for five minutes in 1 to 2000 bichloride. As it has been shown that alcohol is in no sense a germicide and that solution of bichloride of mercury in the strength of 1 to 1000 is not certainly destructive to bacteria even in fifteen minutes, it will be seen that this method is defective.

A method of skin disinfection now used by many surgeons is by the combined use of chloride of lime and carbonate of soda. The chemical union of these salts results in free chlorine gas, which is a reliable germicide. After the preliminary scrubbing with soap and water, about a tablespoonful each of chloride of lime and of carbonate of soda are placed in the palms of the hands, and enough water is added to make a smooth paste. The paste

should be thoroughly rubbed into the skin of the hands and forearms and about the nails for at least five minutes and should then be washed away with hot, sterile water.

The objectionable odor which this leaves upon the hands for several hours may be removed by washing them in water containing about 10 per cent. of aqua ammonia, the chlorine uniting with the ammonia to form ammonium chloride.

The method elaborated at the Johns Hopkins Hospital and brought into quite general use through the efforts of Robb, is much more painstaking, and is correspondingly more effective in the destruction of pathogenic bacteria. Whenever the peritoneum, the joints, the brain, or the medullary canal of the long bones is to be invaded, this method should be used.

The successive steps in this method of disinfection are:—

1. Scrubbing and washing with soap and water.
2. Application of solution of potassium permanganate.
3. Application of solution of oxalic acid.
4. Immersion in solution of bichloride of mercury.

After the mechanical cleansing, the excess of soap should finally be rinsed off with hot, sterile water, and a warm, saturated solution of potassium permanganate should be well rubbed into the skin. This should continue for two or three minutes. By this time the skin will have become stained a deep mahogany brown. It is decolorized by an 8- or 10-per-cent. solution of oxalic acid. The hands should

then be immersed in a solution of bichloride of mercury in strength of 1 to 1000 or 1 to 2000 for five to ten minutes, using the nail brush over the surface and especially about the nails. The simple immersion of the hands in bichloride solution for a few seconds or even a minute or two is insufficient for the destruction of germs. By the most painstaking methods even we can seldom absolutely free the skin from germs, but it can usually be rendered so nearly sterile that the tissues are able to resist the action of the small number of remaining bacteria.

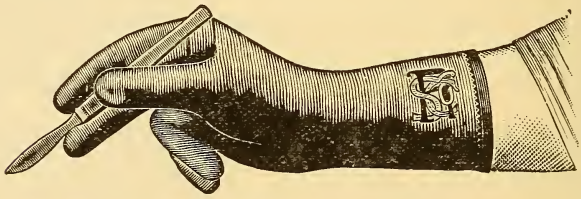


Fig. 15.—Rubber Operating Glove.

Rubber operating gloves have recently come much into favor. By their use, the aseptic technique can be rendered perfect excepting as regards the field of operation. The use of gloves somewhat interferes with the sense of touch, which is so important, especially in abdominal work. They are very useful in making any preparation of the patient after the hands are sterilized. The gloves will protect the hands from any infection and they may be turned off, just before beginning the operation and the hands immersed in bichloride solution. The objection which the surgeon may have to the use of gloves

during the operation does not apply to his assistants. It will lessen the danger of infection if the assistants, who touch the wound or sponges, wear the gloves. They may be sterilized by washing in soap and water and then immersed in bichloride-of-mercury solution of a strength of 1 to 1000 for not less than half an hour.

A still better method is by boiling. The gloves will stand boiling for several times, but are injured to some extent by it.

It is difficult to put the gloves on without tearing them. Some use sterilized French chalk. If this is used it is best done by putting a small quantity into each glove and then tying a piece of tape or wrapping twine tightly about the wrists of the gloves before putting them in the solution to boil. A better method is to place them in a 1-per-cent. lysol solution after boiling. The lysol solution is mildly antiseptic and acts as a lubricant, so that the gloves may be drawn on easily.

Lisle thread gloves have been recommended and used to some extent. They may be sterilized by steam, but, as they soon become soaked during the operation, they take up the bacteria which come to the surface of the skin. It has been found by experiment that the number of bacteria contained in them steadily increases according to the length of time they are worn.

For the disinfection of the field of operation when it is on the external surface of the body, the same method should be used as for the sterilization of the hands of the surgeon, in addition to the preliminary preparation, which will be described in a

subsequent chapter. Even approximate sterilization of mucous surfaces is very difficult. In addition to the preliminary preparation given by the nurse, the vagina should receive the especial attention of the surgeon when the operation is to be made by this route. This will be more fully described under the chapter dealing with vaginal operations.

Disinfection of the Operating Room.—Infection of a wound must come either from contact or from dust floating in the room. There can be little danger from room infection so long as there is no dust floating. Any room in which a major operation is to be performed should be thoroughly stripped of carpets, pictures, and superfluous furniture which may harbor dust. This should be done at least twenty-four hours previous to the operation, that all dust may have time to settle.

After a few hours all the wood-work should be washed with soap and water. This is all that is necessary, but the wood-work may be washed with a solution of mercuric chloride if desired. If there has been a case of infectious disease—as diphtheria, erysipelas, or tuberculosis—in the house, this should not be omitted, and in addition the gaseous disinfection by means of formaldehyde gas should be used.

This may be carried out by vaporizing 16 ounces of formalin to each 1000 cubic feet of space. Instead of formalin, wood alcohol may be used in the proportion of 30 ounces to each 1000 feet. Formalin may now be purchased so cheaply that it is preferable. The room should be tightly closed for twelve hours.

Fig. 16.—Room in Private House Before it is Prepared for Operation.

Fig. 17.—Room in Private House After it is Prepared for Operation.

When an emergency operation must be done immediately, it is better not to remove anything from the room, on account of filling the air with dust and its accompanying bacteria. If there is no carpet on the floor it should be wiped over with a cloth wet with a solution of bichloride of mercury. Should there be a carpet, it should on no account be swept, but should be covered with sheets which have been moistened in bichloride solution.

Operating and Instrument Tables, etc.—All these may be disinfected by soap and water, followed by mercuric chloride solution. In order that the bichloride solution may be effective, towels or cloths should be wrung out of the solution, laid on the surface to be disinfected, and may be allowed to remain there until ready for use. Glass top tables are well sterilized by this method. Tables with wooden tops are not completely sterilized, but should be covered by sterile towels or sheets before being used for dressings or instruments.

Basins, Pitchers, and Instrument Trays. — These may be sterilized by thorough mechanical cleansing and then a prolonged washing with bichloride solution 1 to 1000. It is better to scald each one by pouring boiling water into it and then fill with solution of bichloride of mercury and allow it to stand for fifteen minutes.

Operating Pad and Irrigating Bag. — These may also be sterilized by soap and water and bichloride solution.

The operating pad is one of the most convenient articles in the surgeon's armamentarium, but we would lose nothing in the way of a rigid tech-

nique if its place were supplanted by a rubber cloth covered by a sterile sheet. The operating pad should be covered by sterile towels after the disinfection of the patient has been completed.

The irrigating bag or fountain syringe will withstand boiling, and, unless it is new, this method should be used.

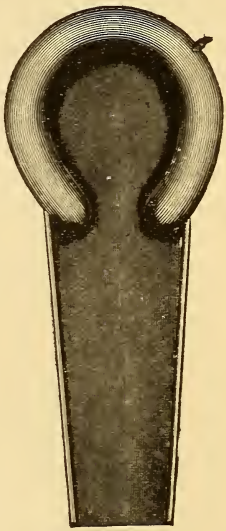


Fig. 18.—Kelly's Laparotomy Pad.

Instruments.—There are various methods for the sterilization of instruments, but, as the simplest is the most efficient, that alone will be described. For all instruments in which it is possible only those which are entirely of metal should be purchased. For knives and some other instruments the plain

metal handles are slippery when wet and in small knives are somewhat heavy to balance the blade.

Scalpels and amputating knives with vulcanized rubber handles baked on to the steel furnish no lodging place for germs. They possess all the advantages of the wood or ivory handles and can be as readily rendered aseptic as those made entirely of metal. Aluminum is attacked by sodium carbonate. Heat, by the means of boiling water, is the simplest way of sterilizing instruments or any other article which is not injured by its action.

Sodium Carbonate, in a 1-per-cent. solution or a teaspoonful to a quart, prevents the rusting of instruments and shortens the time necessary for the sterilization by its solvent action on all organic material.

Many instrument sterilizers are made, but they are entirely unnecessary. Any tin pan or basin large enough to receive the instruments is all that is required. The pan itself is sterilized at the same time as the instruments, and may be used as an instrument tray in the absence of a tray or sterile towels upon which they may be placed. In a private operating room it is convenient to have a tin or copper pan with a wire basket which may be placed inside so that the instruments may be lifted out of the water. Instead of this, the instruments may be placed in a cloth bag, fastened at the top by a tape which is long enough to allow the ends to hang over the side of the sterilizing pan or kettle. The instruments may be lifted from the pan by means of this tape, the water poured from the pan, and the instruments may be replaced in it until ready to be arranged on the tables.

The instruments will be sterilized by boiling water in five minutes, but they may be left longer without harm. The temper of cutting instruments is injured by repeated sterilization by heat. If knives are boiled with other instruments the blades should be wrapped in cotton to avoid dulling.

Instead of sterilization by heat, cutting instruments may be immersed in a 5-per-cent. solution of

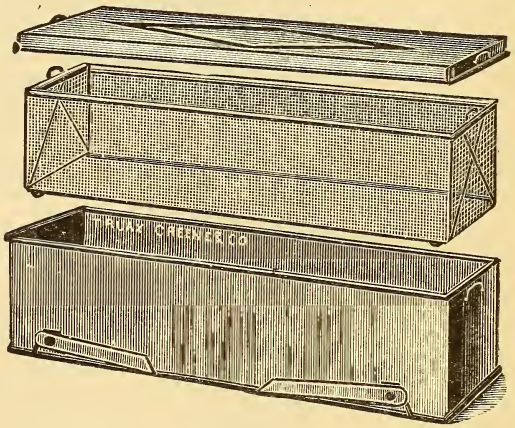


Fig. 19.—Kean's Instrument Sterilizer.

carbolic acid for three hours or a 20- to 40-per-cent. formalin solution for half an hour. The formalin disinfection is preferable.

Disinfection by means of absolute alcohol is inefficient. It inhibits the multiplication of germs, but is not destructive to them.

Operating suits, sheets, towels, dressings, gauze drains, gauze sponges, silk ligatures, and silk-worm

gut sutures may all be sterilized in the steam sterilizer. They should be made into packages of convenient size and wrapped in clean cotton sheeting. This should not contain much sizing and should be thick enough to prevent any contamination through its meshes after the packages are sterilized. Each package should be marked with pencil, so that the required articles may be readily found without opening all the packages.

When pathogenic bacteria are freely exposed to the action of steam at 212° F., all excepting the spore-producing forms are destroyed in fifteen or twenty minutes. But in packages the interior is not so freely exposed to live steam, and the sterilization should be continued for forty-five to sixty minutes.

Silk which is to be used for buried ligatures or sutures and gauze to be left in the wound for packing or drainage should be sterilized, when possible, by the fractional method. The sterilization of these articles would better be done at the place of operation. If for any reason it is impossible to carry a sterilizer, they may be doubly wrapped in cotton cloth, sterilized at home, and carried in the surgeon's bag. The sterilizer takes very little additional room, as it may be packed full of the dressings, etc.

Rubber and Glass Drains may be sterilized in boiling water or in bichloride solution. Silver wire, when used for sutures, may be sterilized by boiling water with the instruments. Silk-worm gut may also be sterilized by boiling water. It is colored and somewhat softened by the soda solution and should be boiled in plain water.

The most reliable animal ligatures are pur-

chased already sterilized in sealed glass tubes. The outside of these tubes may be sterilized by placing them in bichloride of mercury solution for a few moments.

Water for Sponging. — Dry sponging may be employed, or the sponges may be washed in sterile water and squeezed as dry as possible. Water is readily sterilized by boiling it for five or ten minutes. To have sterile water of the proper temperature it is necessary to have a supply which has been previously sterilized and allowed to cool, and also a supply of hot, sterile water. The simplest method of obtaining this in private work is to have at least four nickeled tea-kettles. Two of these may be filled with water and sterilized several hours before the operation. They are then set away to cool. The remainder are for the hot, sterile water. When ready for the operation all these kettles are carried to the operating room, and the water is used directly from them. The water should be strained through several thicknesses of gauze or absorbent cotton before sterilizing. This may be accomplished by tying gauze over the faucet. If this has been neglected, sterile gauze may be tied about the spout of the kettle, and the water is strained as it is poured from it. There is more danger of contamination in this way. If the nickeled kettles cannot be obtained, the water may be sterilized and poured into sterilized pitchers. A sterile towel or cloth should be tied over the pitcher until the water is needed.

Normal Salt Solution.—This may be needed for flushing out the abdomen in cases of purulent infection, as a rectal enema, for injection into the

cellular tissue or directly into the veins in case of shock.

It must be prepared so that 1 or 2 gallons may be available at any moment and of the proper temperature. It is made of the same specific gravity as the blood, and the proper proportion is $^{6}/_{10}$ of 1 per cent. or about 45 grains (3 grammes) to the pint.

Several powders should be weighed out by the druggist, each of which is sufficient for 1 gallon of water. In the absence of these, an even tablespoonful to the gallon is about the right proportion. When the solution is needed, one of these powders should be dissolved in a few ounces of water and sterilized by boiling. This concentrated solution is then set aside until the solution is required. It is then added to 1 gallon of sterile water from the kettles, mixed in such proportion as to give the desired temperature. The concentrated solution is of so small amount that its addition to 1 gallon of water makes very slight difference, either in the temperature or percentage of the salt. When the solution is used in the abdomen it should range from 100° to 110° F. The temperature is often tested by the hand of the nurse, but this is an unreliable guide and it increases the danger of infection. The hands of the nurse, especially if she has been wringing sponges or had them in hot solution, may be so accustomed to heat that the temperature of the fluid may be 120° to 125° F. This temperature will always inflict injury on the peritoneum, and increases the danger of adhesions and infection. The heat should be tested by thermometer when possible.

The thermometer should be a plain glass one of the same style as a clinical thermometer. It is necessary that it should be graduated up to 212° F. to avoid bursting if placed in very hot liquids.

CHAPTER VI.

ACCESSORIES NECESSARY FOR OPERATION.

In hospital practice or when the surgeon can avail himself of the advantages of his own private operating room, the details of an aseptic operation may be much more easily carried out than in the home of the patient. There are, however, no insur-

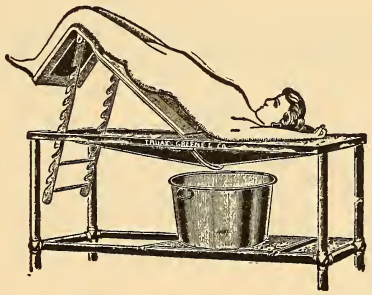


Fig. 20.—Edebohls-Morris Operating Table.

mountable obstacles to perfectly aseptic work, even in the humblest dwelling. This chapter will be devoted to a consideration of the accessories desirable in the private operating room, and to the substitutes which may be used when necessary.

Operating Tables.—The glass top operating tables for operating rooms are not only convenient on account of their perfect mechanism, but for the ease with which they may be cleansed.

The table devised by Dr. Edebohls and modified by Dr. Morris is a good type for the operating room, but is not easily portable.

The Buchanan table is easily portable, as it may be folded into a small compass, and all the positions may be easily secured. It is to be recommended for the small operating room or for the sur-

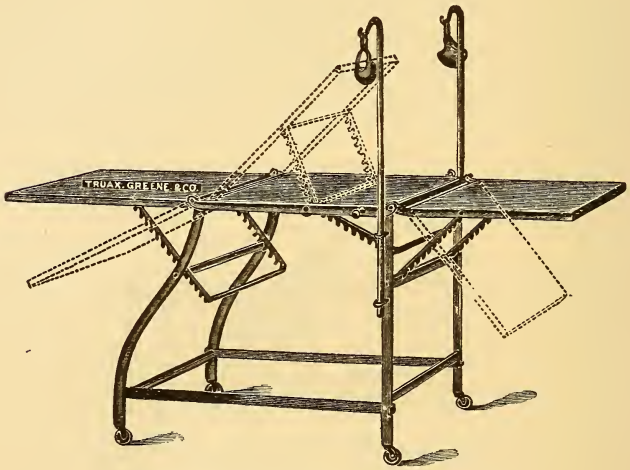


Fig. 21.—Buchanan's Operating Table.

geon who often operates in the home of the patient; but a table of this type recommends itself more from its convenience than from necessity.

An ordinary kitchen table, lengthened, if need be, by a stand, may be used in private houses. If a stand is needed to lengthen the table it would better be placed at the head, and any variation in height may be remedied by the use of pillows. Instead of

using a stand the table may be lengthened by placing on its top a board of the required length and width.

An improvised operating table of this sort is prepared by the usual disinfection, covered with a clean folded blanket, and this in turn by a sterile sheet. A table arranged in this manner compensates, to some extent, for its disadvantages in securing positions by the conservation of the body-heat of the patient, which cannot be well done with the uncovered glass table.

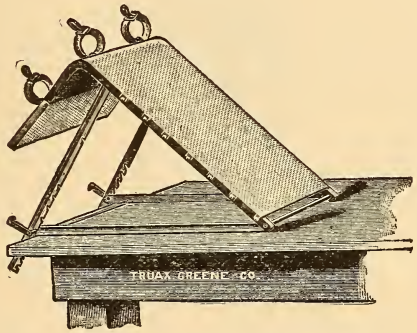


Fig. 22.—Krug's Trendelenburg Frame.

If the Trendelenburg position is necessary it may be secured by the use of Krug's frame.

By means of this device any flat top table may be quickly converted into one which permits the elevation of the pelvis to any desired degree. It may be folded into a small compass for transportation, and is easily clamped to any table.

If this appliance is not at hand, the Trendelenburg position may be secured by raising the hips of the patient and placing a kitchen chair on the table.

The chair should be so placed that its back forms an inclined plane. The top of the chair is under the patient's shoulders, and his legs, bent at right angles at the knee, hang over the rounds of the chair. The rounds of the chair should be covered by a pillow, or a sheet or blanket may be tightly pinned about the four legs of the chair in such a manner that it covers well the bottoms of the chair legs. By the

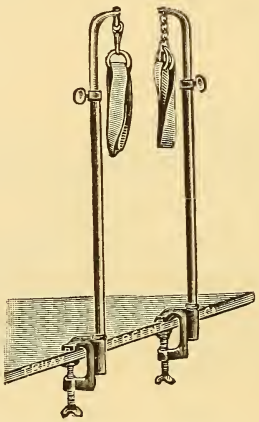


Fig. 23.—Edebohls's Lithotomy Crutch.

use of a chair in this manner a Trendelenburg position of from forty to forty-five degrees is obtained.

The dorsal position for operations by the vagina or rectum may be secured in a variety of ways. Edebohls's leg holders may be had, and may be attached to any table. Robb's canvas operating strap is a convenient leg holder and takes very little room in the operating bag.

The operating strap is made of heavy Canton

flannel of double thickness and closely quilted. It is about six feet in length and three inches wide in the center, gradually tapering toward the ends. It is made adjustable to any patient by means of snaps at each end and by metal rings attached to the strap by strong tape. The strap is passed over the neck of the patient and the ends fastened around each thigh just above the knee by means of the snaps and rings.

If neither of these appliances is at hand, the

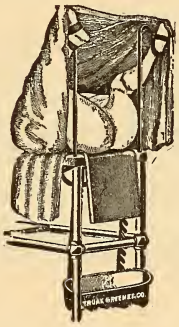


Fig. 24.—Position for Vaginal Operations.

Robb leg holder may be replaced by a sheet, folded diagonally like a cravat. It is placed over the neck and the ends tied around each thigh.

Tables for Instruments and Dressings.—An abundance of table room renders the maintenance of the technique much less difficult than when a variety of articles must be placed together and frequently handled. The same remarks apply to instrument tables as were made of operating tables. The glass top tables may be sterilized so that instruments may

be placed directly on the table. If the wooden tables are used, they should be well covered with sterile towels before the instruments are placed on them. The towels should completely cover the top of the table and overhang the edges. In private houses, if ordinary small tables or stands are used, six are none too many, although two will do if unable to obtain

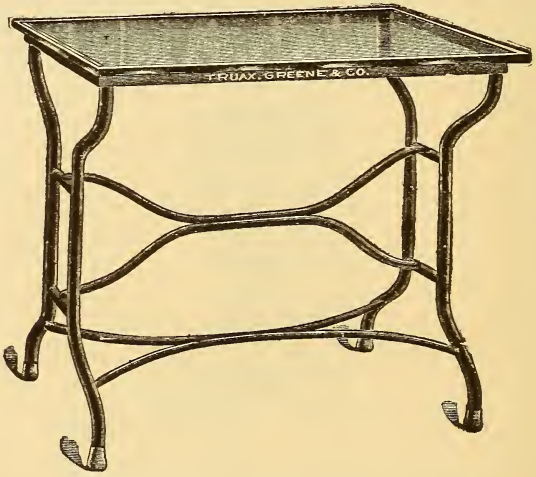


Fig. 25.—Glass Top Instrument Table.

more. Wooden chairs which have been covered by clean sheets may be used instead of tables, for basins containing the sponges or the solutions for the hands.

Basins, Pitchers, and Operating Trays. — Not less than six wash-bowls or basins should be provided, and an equal number of pitchers may be needed for solutions. If nickeled kettles are used for the sterile

water, four pitchers will be sufficient. Usually this number of basins and pitchers may be found at any house or readily procured in the vicinity. The surgeon can easily carry several basins of granite ironware or agateware. If they are of uniform size and shape they occupy very little room when nested.

Usually, when an abundance of sterile towels may be had, the most convenient method of arranging the instruments is on the table covered with sterile towels. Instead of this the instruments may

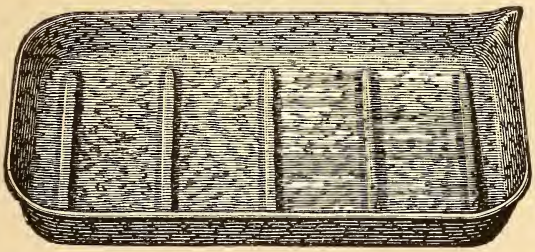


Fig. 26.—Agate Instrument Tray.

be placed in an instrument tray furnished by the surgeon or on a large platter found in the house. A separate plate for ligatures and sutures avoids annoyance.

Several nickeled kettles are a convenience. The water may be sterilized in these and used directly from them instead of using from pitchers. Every transfer of this nature, especially with untrained assistants, adds to the uncertainty of the result. An ordinary tin pan may be used for sterilizing the instruments, or the instrument tray or one of the

agateware basins carried by the surgeon may be used for this purpose.

Irrigating Apparatus. — Almost any wound may require irrigation, and some apparatus should al-

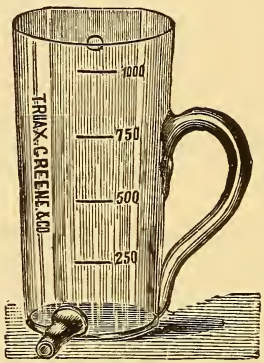


Fig. 27.—Glass Irrigator.

ways be available. For the private operating room a glass or porcelain irrigator that will hold three or four quarts is best. The best form is a graduated pitcher with an outlet near the bottom to which a

Fig. 28.—Glass Irrigating Pipe.

piece of rubber tubing may be attached. This rubber hose may be slipped off and sterilized by boiling before each operation.

A variety of irrigating nozzles may be had. The

best for general use is a plain glass one with a large opening. The glass portion of a medicine dropper may be used. If the opening is too small the end may be broken off.

The more portable irrigating appliances are Lee's siphon syringe and the fountain syringe. The Lee siphon is like an ordinary bulb syringe, but is provided at its distal end by a U-shaped clip, by means of which it may be attached to the rim of a pitcher or pail. In the absence of any irrigating

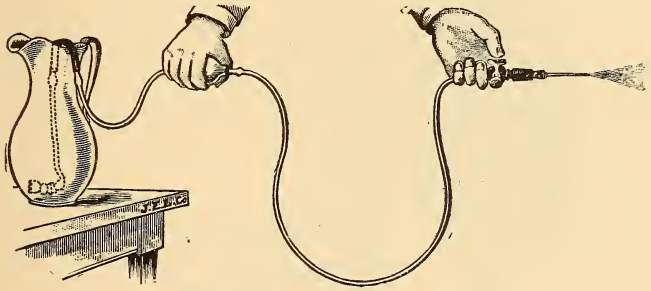


Fig. 29.—Lee's Siphon Irrigator.

apparatus, the liquid may be poured into the wound from a pitcher.

Operating Suits. — The surgeon and his immediate assistants should wear operating suits which completely cover the street clothing. It is better to have clean gowns for all invited guests, but it is not indispensable unless they come in contact with the assistants, the operating table, or other aseptic paraphernalia.

The suits may be either made with coat and pants or simply a gown. The gown is most conven-

ient, and if made large about the neck, and tied with tape at the waist, it may be made to fit any person. It should reach below the knees, and the sleeves only to the elbows. Heavy drilling or white duck is the best material for these suits. If the suits are not at hand, white duck coats—which may be found at almost any clothing store—may be used, or a sterile sheet may be folded so that it will give the proper

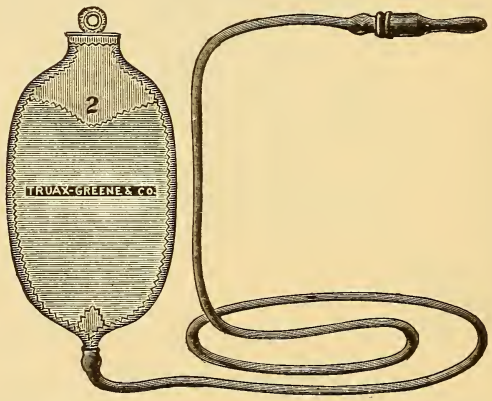


Fig. 30.—Fountain Syringe Arranged as an Irrigator.

length, pinned at the shoulders and tied about the waist with tape.

Sheets and Towels.—At least three sheets should be provided. For an abdominal operation a laparotomy sheet with a circular opening in the center may be used to advantage. Instead of this a gauze diaphragm may be used. A piece of sterile gauze two or three feet square may be used to cover the abdomen and a circular or oval piece cut out over the site of the incision. An abundance of towels

should be provided. Usually two dozen are needed. They should be sterilized in packages of one-half dozen each.

Two or three nail brushes should be at hand. They should either be new or should be soaked for an hour or more in bichloride solution. It is better to purchase cheap brushes, which can be thrown away and new ones used for every major operation.

Fig. 31.—Surgeon's Operating Gown.

Two slop buckets are necessary, one to be placed so that the fluids from the operating table may drain into it, and the other to be used for the reception of the discarded sponges and fluids.

A plate or other receptacle should be in readiness for the reception of any diseased tissues to be removed.

CHAPTER VII.

GAUZE, SPONGES, LIGATURES, AND SUTURES.

ABSORBENT gauze may be purchased in packages of five, twenty-five, or one hundred yards. It is used for dressings, bandages, compresses, gauze sponges, and gauze and cotton mops. In abdominal operations it is useful for walling off the field of operation from the other portions of the peritoneal cavity. A long strip may be used for dry sponging instead of gauze sponges. For these purposes, several pieces of gauze one yard or more in length, and hemmed at each end, are useful.

Absorbent Cotton is used as a dressing and also sometimes in the composition of sponge substitutes. When sterilized for a dressing it should be cut of the proper size before sterilizing. It cannot be effectually sterilized in the roll unless exposed to the action of steam for a long time.

Sponges and Sponge Substitutes.—The use of marine sponges in all major operations has been almost entirely discarded. They cannot be sterilized by heat on account of the shrinking and hardening which it causes.

Chemical disinfection is inefficient. If they are to be used it is better to purchase the so-called "aseptic" sponges, which are sold by all dealers in surgeons' supplies. These are not sterile, but they have been properly cleansed of sand and other ex-

traneous matter. To render them reasonably sterile they may be soaked for an hour in a 1-per-cent. solution of potassium permanganate, decolorized in a 2-per-cent. solution of oxalic acid, rinsed in sterile water, and preserved in a 1 to 1000 bichloride solution or a 3-per-cent. solution of carbolic acid. Marine sponges may always be replaced to advantage by one of the substitutes.

Gauze Sponges are made from absorbent gauze, folded in several thicknesses and the edges either hemmed or so folded that the cut edges are all turned in, and the sponge retains its shape without stitching.

Several sizes are convenient, and for this purpose the gauze should be folded double and cut in rectangular pieces from nine to twelve inches square. If the sponges are to be sewed, these pieces of gauze may be folded in any manner that makes the sponge of the desired size.

If the sponges are to be folded and not stitched, considerable care is necessary to fold all the rough edges inside. A convenient way is to cut a strip of gauze about eighteen inches wide and of any desirable length. This is folded lengthwise in the middle to make a double thickness. It is then folded in thirds, the free edges being folded in first. We now have a long strip of gauze about $2\,^3/_4$ to 3 inches wide. This strip is now cut into pieces about 6 or 8 inches long. This is folded crosswise in thirds, making a pledget of gauze about 3 by $3\,^1/_2$ inches in size. Now pick up one thickness of gauze, and, holding the remaining portion firmly, turn the pledget inside out. This leaves ragged edges at one

end; so, picking up the double thickness of gauze at the other end of the pledget, it is again turned inside out, thus covering up the cut edges, and the sponge is completed. Large flat compresses, made like the sponges, but five or six inches square, are sometimes useful for protecting the intestines.

Gauze and Cotton Mops are made by wrapping absorbent cotton in squares of gauze. The corners are brought together and tied with thread and then cut off close to the thread. These may be bought

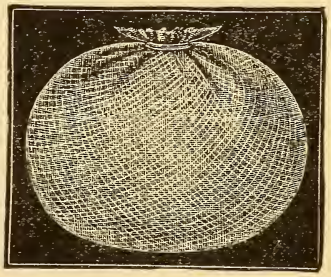


Fig. 32.—Gauze and Cotton Sponge Substitute.

in any size from one-half inch to three inches in diameter for a little more than the cost of the materials.

Iodoform Gauze. — It has been sufficiently emphasized that no antiseptics are necessary or should have any place in an aseptic operation. This is always true when only tissues which are free from germs are implicated in the operation. In such cases plain sterile gauze is much to be preferred, either for drainage or for packing of the wound. When a pus-cavity must be drained, or the wound

is in tissues which cannot be freed from bacteria and kept sterile, iodoform gauze may be of use. Iodoform does not destroy bacteria, but it inhibits their growth. When iodoform gauze is used it should be sterilized in the same manner as the plain gauze.

Gutta-percha Tissue is useful as a protective over wounds and also in making the wick drainage after the method of Dr. Robert T. Morris.

It may be sterilized by soaking in 1 to 1000 solution of bichloride of mercury for not less than one-half hour. The solution in which it is soaked must be cold, as hot solution ruins the tissue.

White Cotton Wadding, such as is used by tailors, makes a very smooth dressing when applied over absorbent gauze. It is not absorbent, and should not be used when drainage is employed.

Ligatures and Sutures.—Silk and catgut are used for ligatures; and silk, catgut, kangaroo tendon, silk-worm gut, and silver wire are used for sutures.

Aseptic sutures or ligatures of non-absorbable material are usually encapsulated in the tissues and cause no irritation, but they may give rise to suppuration and be the exciting cause of a chronic sinus which will persist until the offending substance is discharged or removed. The difficulty in securing aseptic absorbable ligatures and sutures, and the danger of too rapid absorption, has in the past led many surgeons to rely almost entirely upon those which are non-absorbable. By the improved methods of sterilizing and preserving catgut both these objections are overcome, and very little is left to be desired for buried sutures and ligatures. For skin sutures and certain operations in which a permanent

suture is desired some other material may be preferable.

Silk is very freely used by many surgeons. It can be certainly sterilized by steam or by boiling when needed in an emergency. It has the advantage of tying securely and with a small knot. From its strength it may be used of a small size and in a needle which will not cut the tissues. For this reason it cannot be well replaced in intestinal work. In most other work it may advantageously be replaced by some other material. The most convenient way to sterilize and preserve silk sutures is to wind various sizes on small glass spools. These are

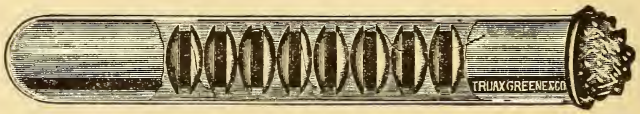


Fig. 33.—Test-tube with Glass Spools for Sterilizing Silk.

placed in a large ignition test-tube, plugging with non-absorbent cotton. They are sterilized in the steam sterilizer, preferably by the fractional method.

Silk-worm Gut is almost an ideal non-absorbable suture. It is very strong and is easily sterilized. There are no open meshes, and it offers no lodging places for bacteria, should the wound become infected. It comes in three sizes. The medium size is generally sufficient for all purposes.

If it is sterilized by steam, a sufficient number of strands should be selected and the curled ends cut off. The bundle of strands may then be doubled once and placed in a test-tube, or may be rolled in

a coil and wrapped in muslin to be sterilized with the dressings. It may be very quickly sterilized by boiling for five minutes, just previous to the operation; it should be boiled by itself, and not with the instruments, as the soda solution colors and softens it.

Silver Wire, which was an old-time favorite, has nearly gone out of use as a suture on account of the difficulty in its introduction and removal.

Recent experiments have shown that metallic

Fig. 34.—Coil of Silk-worm Gut.

silver has an antiseptic property of its own, and for a permanent buried suture this should give it a claim. For external sutures and for the closure of fistulæ *silk-worm gut* possesses nearly all the advantages of silver wire and is much more flexible.

Silver wire would be an ideal permanent buried suture were it not for the pain and irritation which may be caused by its twisted ends. It is especially adapted to uniting bony surfaces. The ends after being twisted are hammered down flat against the surface of the bone, or a slight excavation may be

made with a gouge for the reception of the knot. Some operators also use silver wire as a buried suture in operations for hernia and for closing ordinary abdominal incisions. It may be sterilized in the soda solution with the instruments.

Catgut is the most useful material we possess for sutures and ligatures, and it is also the most difficult to sterilize, since, being made from the intestine of the sheep, it furnishes an excellent soil for all kinds of bacteria. Until recently there has been no method known by which the microbes could be with certainty destroyed without destroying also the strength of the material. The manipulation necessary is so lengthy and requires such extreme care and special apparatus that only one who is a master of aseptic technique and has had experience in this work can successfully prepare it. As this is intended as a guide for the general practitioner, no minute description of the preparation will be made.

Until recently it was impossible to obtain a reliable article from dealers, as the workmen were ignorant of the necessity for absolute asepsis, even if they had been taught the technique. Moreover, if a quantity of aseptic catgut was secured, it was almost impossible to preserve it in that state for repeated operations, as it was apt to become contaminated by the repeated opening of the containers. It was for these reasons that catgut was almost wholly discarded in most of our leading hospitals, several years ago, and is even now only slowly coming into favor. Another objection to catgut was the liability in some instances of too rapid absorption.

By methods of preparation and preservation

which have been elaborated within the past few years all these objections have been overcome.

There are three reliable methods of sterilizing catgut. These are by boiling in *cumol*, treating by *formalin* solution and afterward boiling in water, and by boiling in *alcohol* in sealed tubes under pressure and at a high temperature. The catgut can be sterilized with certainty by any of these methods, but it can be preserved in a sterile condition better when sterilized in alcohol in hermetically sealed glass tubes. The catgut is also hardened by either of the other methods, and the period of absorption is lengthened. This may be an objection for some purposes, and for others it is to be desired.

Cumol is a coal tar derivative with an exceedingly high boiling point: about 170° C., or 238° F. After sterilizing, the catgut is preserved in sterile bottles or jars, either in alcohol or benzine. Several years ago Dr. Howard A. Kelly discarded catgut as a suture and ligature material, but he has declared recently that the discovery of the process of sterilization by cumol has made it the best suture and ligature material for general use.

The preparation of catgut by the formalin method depends not upon the antiseptic properties of the formalin, but upon the fact that it hardens the catgut so that it may be boiled in water without injury. The catgut is soaked for several hours in a 2-per-cent. solution of formalin, and then boiled for half an hour in water, and preserved in alcohol.

Dr. J. H. Carstens, of Detroit, is an ardent advocate of catgut sterilized by the dry heat method of Boerckmann. The catgut is soaked in ether for

a week to remove the fat. The strands are then wrapped in fine tissue paper, put in an envelope, and sealed. These envelopes are then put in a Boerckmann sterilizer and subjected to a heat of 300° F. for three hours on two successive days; and when ready to use the end of the envelope is torn off and the tissue paper containing the ligature is dropped into alcohol, from which it may be used. Catgut

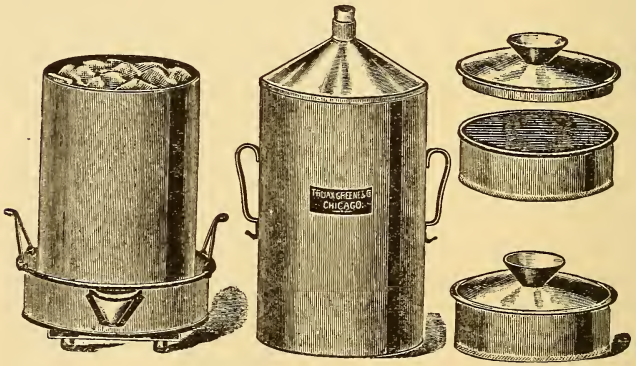


Fig. 35.—Boerckmann's Sterilizer, with Box for the Dry Sterilization of Catgut.

prepared in this manner may be obtained from Truax, Greene & Co., of Chicago.

An ideal method of sterilizing and preserving catgut is by boiling it in alcohol under pressure. Alcohol boils at 174° F., and that temperature is not sufficient to sterilize the catgut. To accomplish this the catgut is wound on a glass spool and placed in a glass tube nearly filled with alcohol. The upper end of this tube is hermetically sealed, and it is then

placed in an autoclave and subjected to a temperature of 248° F. for an hour. As the tube is hermetically sealed, its contents are preserved in an aseptic state for any length of time. If it is desired to increase the length of time required for absorption, the catgut may be treated with a solution of bichromate of potash before it is sterilized. It may also be obtained *half-chromicized* when it is not desirable for absorption to be delayed for several weeks.

This process of sterilization is so complicated that it cannot be carried on by the physician, and he must, therefore, depend upon some reliable manufacturer to prepare his sutures for him. There are a number of firms that prepare the catgut after this method, and, so far as I know, the product of all these is reliable. For several years I have used the catgut prepared by St. John Leavens, of New York, and can commend it as being perfectly reliable. This product may be had in three sizes, either plain or chromicized. Each tube contains one meter, or about thirty-nine inches, of catgut. When it is to be used a sufficient number of tubes are placed in a bowl of bichloride solution to sterilize the outside of the tubes. The tubes may be broken by grasping each end by a sterilized towel. The catgut is somewhat stiff from the effect of the alcohol, and especially is this true of the chromicized gut. If it is dropped in sterile water and allowed to remain for two or three minutes, it will become pliable and will tie more closely. As the remnants of the unused ligature must be discarded, only as many of the tubes should be broken before the operation commences as will certainly be required.

The expense of catgut prepared in this way may be a valid objection to its use in hospital practice, but its advantages are so great that this small item should not prevent its use. The danger of contamination of the contents of the receptacle, while removing the ligature for repeated operations, is not small, and the danger is increased by the carelessness begotten by the general opinion that alcohol, or whatever liquid in which the ligature is preserved, is an antiseptic capable of destroying any germs which might gain access to it. It must be remembered that alcohol is not destructive to germs, but only inhibits their growth. It will therefore preserve, in a sterile condition, any article that has been completely freed from germs, but it will not act as a germicide. Catgut which is kept in glass tubes with rubber caps, and intended to be drawn from the tube as used, is not to be relied upon.

Kangaroo Tendon was introduced as a suture by Dr. Henry O. Marcy, of Boston. He especially commended it as a suture in hernia operations on account of its long resistance to absorption. It may be prepared in the same manner as catgut and is furnished in the hermetically sealed tubes by Van Horn & Co., of New York, and several other houses. Its tensile strength is greater than that of catgut, and, since it consists of longitudinal bands of fibrous tissue, it can be divided into any desirable size.

The process of absorption of animal ligatures takes place by infiltration by round cells and leucocytes, and the rapidity of the process depends largely upon the blood-supply of the parts. Absorption is most slow in the subcutaneous tissues and fascia,

while it is quite rapid in the skin and still more so in the mucous membranes.

The length of time required for absorption increases very rapidly with the size of the catgut used.

Dr. Hugh Cabot, of Boston, has recently experimented quite largely with catgut buried in the muscular tissue of rabbits. He found that No. 2 catgut requires from two to three times as long for its absorption as did that of the No. 1 size. His conclusions are as follows: 1. That in the flesh of rabbits No. 1 chromicized catgut is retained longer than is desirable in a suture material for surgical use. 2. That plain catgut of No. 1 size is retained a sufficient length of time; that is to say, a minimum of three weeks. 3. That catgut sterilized by dry heat is more rapidly absorbed than that prepared by the moist methods. 4. That the time required for absorption increases very rapidly with the increase in size.

As the different firms who prepare catgut have various methods of numbering the sizes, No. 2 must be substituted for No. 1 in his conclusions, if the numbering in the particular article used commences at No. 1. The varieties which Cabot used were numbered from No. 00 up to No. 3: a very confusing method.

It follows from the foregoing that the size and preparation of catgut to be used should depend upon the time it is desired to have its strength retained, and the vascularity of the tissues in which it is to be placed. For the peritoneum and small blood-vessels the No. 1 size of Leavens's plain catgut will be sufficient, while for the skin and larger vessels the No. 2

should be used. For the mucous membranes and larger arterial trunks the No. 2 chromicized or the No. 3 plain gut should be used, and for uniting the fascia of an abdominal wound or hernial opening I prefer the No. 1 chromicized gut on account of its small size, its tensile strength, and its lengthened resistance to absorption.

CHAPTER VIII.

DRAINAGE OF WOUNDS.

It was formerly considered necessary to drain all abdominal wounds whether infected or not. It was supposed that the serous oozing which follows an abdominal operation must be removed or it would decompose and cause peritonitis.

The experiments of Wegner and Muscatello, which have been cited, prove that enormous amounts of sterile fluids may be absorbed by the peritoneum, and that considerable quantities of septic material may also be absorbed.

Muscatello's demonstration of the absorptive power of the diaphragmatic peritoneum was utilized by Dr. J. G. Clark in his postural drainage, and the absorption of septic material was increased by diluting it with sterile salt solution. This postural drainage is carried out by leaving from one to two pints of salt solution in the abdomen and by raising the foot of the bed eighteen inches.

The knowledge of this ability of the diaphragmatic peritoneum to rapidly absorb all fluids which are brought in contact with it may be of service in a class of cases in which the greatest danger is not from peritonitis, but from an acute toxæmia from the overwhelming amount of bacteria and their toxins which have gained access to the wound. These

cases should be treated in a directly opposite manner, by free drainage and by elevating the shoulders so that the absorption of the infectious material may be retarded as much as possible.

It must be remembered that in many chronic suppurative cases the pus has become attenuated and very nearly sterile, and also that some micro-organisms are incapable of proliferating on the peritoneal surface. This is especially the case with the gonococcus. It is much safer to trust the peritoneum to absorb and destroy small quantities of septic material than to trust to a badly managed drain.

Especially is this of importance to the country surgeon, who must operate where he cannot have charge of the after-treatment, and has reason to fear the technique which will be carried out by the attending physician.

It is entirely unnecessary to provide for the removal of the sero-sanguineous oozing which follows an abdominal operation, and the presence of any foreign body excites a freer flow from the wounded surfaces than would otherwise take place. The drain is usually a very inefficient means of removing fluid from the abdomen, as it must work against gravity and it often acts as a plug to cause its retention; its presence gives an open door to the entrance of germs which may find their way into the dressings or may reach the wound during its dressing; it holds asunder tissues which might be brought in close apposition and, therefore, it increases the dangers of ventral hernia; from the irritation of the peritoneal surfaces which it causes it favors adhesions which may become the cause of intestinal obstruction; from

pressure on the intestinal coats it may cause a fæcal fistula; the removal of a drain is always painful, as the gauze drain quickly becomes adherent to the peritoneal surfaces and portions of omentum may press through the openings of a glass drain. If a glass drain is used, it should be turned at each dressing.

There are two classes of cases where a drain is indispensable. It should be used to drain abscess-cavities, which are shut off from the peritoneal cavity and cannot be enucleated, and in wide-spread peritoneal suppuration. Whenever it is possible, the aid of gravity should be invoked. If suppuration is in the pelvis it may be drained through the vagina, either with or without drainage through the abdominal incision. If the suppuration is in the lesser peritoneal pouch, either as a result of suppurative inflammation of the gall-bladder, liver, or pancreas, or from extension of an appendical abscess, the same result may be obtained by a lumbar incision. This may be made as a "lumbar stab" from within, under the guidance of the fingers, or the surgeon may gradually dissect from without inward on to the end of the finger which is placed at the desired point inside the abdomen. Drainage is best secured, through a lumbar incision, by a rubber drainage tube.

After a suture of the gall-bladder or its ducts, or after an intestinal anastomosis from which it is feared a leakage may take place, it is well to place a provisional drain, to be removed in two or three days if the union seems secure.

For securing drainage, we may use glass or

rubber tubes, gauze, lamp wicking, rubber tissue, or a combination of these methods.

Glass Drainage Tubes are not often used at the present time. They are especially useful, however, in draining a localized suppurating area deep in the abdomen, where the pressure of the abdominal con-

Fig. 36.—Glass Drainage Tube.

tents would prevent drainage by gauze or wicking. The tubes are usually curved, and should be from $^1/_4$ to $^1/_2$ inch in diameter, and from 4 to 6 inches in length. The fenestra should not be more than $^1/_{20}$ or $^1/_{25}$ inch in diameter. When they are larger than this, minute herniæ of the omentum are apt to occur through the openings.

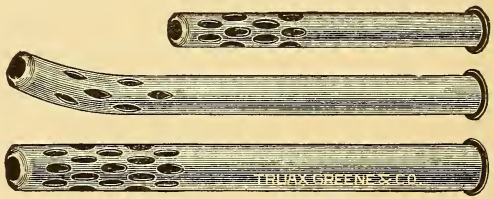


Fig. 37.—Murphy's Glass Drainage Tubes.

In order for a tubular drain to be effective, it must be frequently cleansed or it may be supplemented by gauze drainage within the lumen of the tube or beside it. The capillary attraction of a lamp wick which loosely fills the tube and communicates with a copious absorbent dressing greatly assists the

drainage. If this is not used, the best method of removing the liquids which fill the tube is by means of pledgets of sterile absorbent cotton held in slender forceps, or by a suitable suction syringe.

If there is much oozing, this cleansing will be necessary every twelve or twenty-four hours and must be done with as strict regard to asepsis as is

Fig. 38.—Slender Forceps for Drainage Tube.

the original operation. The glass drainage tube may be boiled, or it may be sterilized by immersion in solution of bichloride of mercury 1 to 500 for one-half hour.

The Rubber Drainage Tube is more often used than glass on account of its flexibility, and the fact that it may be cut of the desired length. From its

Fig. 39.—Hard-Rubber Syringe for Cleansing Drainage Tube.

flexibility it may be carried into a cavity in any direction, and is less liable to cause gangrene of the intestine and fæcal fistula than is the glass tube. It may be had in sizes from three-sixteenths to one-half of an inch in diameter, or ordinary rubber tubing of the desired size may be fenestrated at intervals of one-third of an inch. If the drainage tube has

been omitted in the list of articles to be provided, one may always be made from a piece of the tubing of the fountain syringe. The tube may be sterilized in the same manner as the glass tube, but best by boiling for five minutes. The same principles apply to the cleansing of the tube as to the glass drains.

Fig. 40.—Rubber Drainage Tubes.

All the remaining varieties of drains act by capillary force, and much of their efficiency depends upon their communication with an absorbent dressing which is changed so often as never to be saturated. In order to obtain the full benefit of capillary drainage it is necessary to employ a small

Fig. 41.—Hamilton's Drainage Tube Carrier.

drawing column of absorbent material in the interior of the wound, with a large *receiving mass* of absorbent material placed in contact with it, outside the wound. The receiving mass must be changed when it becomes saturated to the point of decreased absorbing power, otherwise it will have little effect upon the drawing column within.

Gauze Drains may be made either of plain sterile gauze or of iodoform gauze. It is usually better to follow the simple aseptic rules and use no chemical disinfectants. The gauze strips may be used in any length and width to suit the operator, and to accomplish the end he has in view.

The most convenient way is generally to use a strip, cut from one and one-half to two inches in width and from eighteen to twenty-four inches long. This is folded twice and stitched along the edge. When it is inserted, it should be so packed in the cavity to be drained that in its removal it will not become entangled and cause injury to the granulating tissues. This may be accomplished by packing the gauze strip around the cavity to be drained, and, last, the center of the cavity, so that, as the strip is withdrawn, it will unfold, much as when a ball of twine is unrolled from the inside of the ball. Great care must be exercised, lest the gauze is packed so tightly in the opening of the abdominal wall that it act as a plug and cause retention of the fluids which it is intended to remove.

Sometimes it will be necessary to terminate an operation quickly and before perfect control of hæmorrhage from a large denuded surface has been secured. Gauze packing may be used with considerable pressure to accomplish this. When used in this way, it is well to line the cavity to be packed by a single layer of gauze and then pack the strips into this as a bag would be filled. When the packing is to be removed the strips may be pulled out one by one, and finally the gauze lining the cavity may be removed.

The Mikulicz gauze drain is made in the manner I have just described, only the gauze strips are packed loosely.

Lamp Wicking may be used instead of gauze, and should be inserted in the same manner. Dr. Robert T. Morris uses what he calls the *gauze wick drain.* It is made of a strip of gauze which, when loosely folded, is about as large as a lead pencil, and this strip of gauze is rolled in gutta-percha tissue much as one would roll a cigarette. The gauze projects at each end a little beyond the rubber tissue, and small openings are snipped in the gutta-percha covering, after it has been rolled, so that fluids can enter at more than one point. The gutta-percha covering prevents the adhesion of the gauze to the peritoneal surfaces, and, by directing the current, it increases the capillary attraction of the gauze. The gauze strip should be sterilized by steam, and the gutta-percha tissue by immersion in a 1 to 500 solution of bichloride of mercury for an hour. This solution should be cold.

The gutta-percha tissue alone makes a very good drain when simply folded in several thicknesses. Its capillarity is not great, but it serves to keep the wound open and forms a smooth plane along which the fluids find their way to the surface, following the line of the least resistance.

Removal of Drains.—As soon as the objects of drainage have been accomplished the drain should be removed. If an abscess-cavity is to be drained, it is usually safe to remove the drain in a few days, and simply keep the external opening patent by loosely packing with sterile gauze, or by a strip of

rubber tissue. The walls of the cavity to be drained quickly fall together from the pressure of the intestinal coils, and the fluids are forced out of the opening. A persistent sinus is often caused by allowing the drainage tube to remain too long or by too persistent packing of the cavity to its bottom.

CHAPTER IX.

DRESSING OF WOUNDS.

THE objects of surgical dressings are to protect the wound from mechanical injury, to prevent the entrance of germs from without, and to absorb the discharges from the wound. If the wound is closed without drainage, the first two objects are the principal ones.

If drainage is used or if much oozing from the wound is to be expected, an abundant absorbent dressing must be used. The principal dressing materials, which are now almost universally used, are absorbent gauze, absorbent cotton, cotton wadding, and the various medicated gauzes. Some surgeons also use oakum. Absorbent gauze and cotton answer all the requirements for a good dressing and no other materials are necessary. In the absence of these, clean linen or cotton cloth may be sterilized and used in their place. Sometimes the medicated gauzes, iodoform, sublimate, carbolic acid, or formalin may be used.

The dressing may be made by placing a layer of absorbent cotton between two layers of gauze, stitched about the edges, or several layers of gauze may be placed next the wound and covered by a sufficient amount of cotton to absorb all discharges from it. If the wound must be drained, or is one from which much oozing may be expected, a suffi-

cient amount of dressing must be used so that it will not become saturated.

If the discharges wet through the dressing, conditions become favorable for the development of bacteria in it and consequent infection of the wound.

An Occlusive Dressing may be used if drainage is not necessary. This successfully protects the wound from mechanical irritation and from infection from without. It is especially useful in places where the wound cannot be well protected by ordinary dressings. It is to be commended in harelip operations, in operations for hernia, Alexander's operation, suprapubic cystotomy, and symphysiotomy. The only objection to its use is the difficulty in removing it. If Halsted's subcutaneous suture is used, the dressing may be allowed to remain until it becomes loosened. It must be carefully watched, however, to make certain that there is no suppuration beneath it. If it is necessary to remove it, it may be softened by applying a pledget of cotton saturated with equal parts of absolute alcohol and ether. The occlusive dressing is made by applying several layers of gauze saturated with collodion or celloidin.

Celloidin may be made by the following formula:—

℞ Squibb's ether,
Absolute alcohol, of each, 50.00 cubic centimeters.—M.

Add gun-cotton slowly until the mixture is of the consistency of simple syrup. If it is desired to add some antiseptic, 6.25 grammes of iodoform may

L. of C.

be added or 0.25 cubic centimeter of the following solution:—

℞ Cryst. hydrarg. bichloridi, 1.00 gramme.
Absolute alcohol, 40.00 cubic centimeters.—M.

The best method of applying this dressing is as follows: After the wound has been thoroughly dried, a piece of sterile gauze or crape cloth is placed over it. Upon this is poured some of the celloidin and distributed over the surface by a glass or steel spatula. Over this is placed another layer of the gauze and celloidin and finally the ordinary dressing. As there is no necessity for an absorbent dressing, the cotton wadding makes an excellent covering.

Bandages are used to retain dressings in place and sometimes to exert pressure. If only for the retention of dressings, some light material like gauze is best. If much pressure or firmness is desired, they may be made of muslin, cotton flannel, or wool.

Wounds of the extremities, head, neck, and some parts of the trunk are covered by the roller bandage. Gauze or muslin bandages of any desired width may be purchased or may be cut by drawn thread.

For abdominal wounds, the simple straight binder, the T-bandage, or the Scultetus bandage may be used. If the simple binder is used, it is very apt to slip up, and should be held in place by a strip of cloth passed around each thigh and pinned to the lower part of the bandage over each trochanter.

The Scultetus bandage is made of eight pieces of cloth, each four inches wide and from twenty to thirty inches in length, according to the size of the patient. Six of the strips are laid edge to edge, each strip overlapping the next by one-half its width, and sewed to two perineal strips crossing the abdominal strips at right angles in their center.

This bandage is applied by crossing the upper straps diagonally downward over the abdomen so that they will lie flat. The next two straps, when crossed, will overlap these, while the lower one will pin straight across. Only the lower straps need be pinned. The abdominal straps are held in place by the perineal straps, which are drawn firmly between the thighs.

All abdominal bandages should be made of some material which is not heavy enough to be uncomfortably warm to the patient, but firm enough to exercise some pressure. If it is of loose texture, it is much more easily pinned. The best material is thin, white, cotton flannel, sometimes called outing flannel.

CHAPTER X.

PREPARATION FOR OPERATION BY THE NURSE.

That a faultless technique may be carried out, it is necessary that the preparation be made in a methodical manner, so that each step prepares for the next. It is also necessary that the nurse should understand the method of the surgeon, lest confusion and uncertainty should result.

At the risk of appearing somewhat pedantic, a plan of preparation will be outlined, both for the nurse and the surgeon and his assistants.

It will be assumed that an abdominal operation is to be performed in a well-furnished private house and with the aid of a professional nurse. If it should be impossible to secure an efficient nurse, a part of the preparation may be intrusted to some intelligent woman, while the most essential part of the preparation must be made by the surgeon himself, or by a trustworthy assistant.

Should it be impossible to secure everything to be desired, the ingenuity of the operator will furnish some substitute.

We will suppose that the operation is to be performed at 9 A.M. The nurse should be in attendance, when possible, at least twenty-four hours before the time appointed. She should be furnished by the surgeon with a written list of the number of tables, towels, sheets, basins, and all other articles

which he will require. If she is not familiar with his particular method, he should instruct her in regard to the principal details. Unless this is done, confusion and uncertainty may result from a preparation which may be equally thorough, but not adapted to the methods of the surgeon.

The nurse will be very grateful for these suggestions if she is not given the impression that the surgeon considers all other methods defective. The first duty of the nurse should be to secure all the articles in the list supplied by the surgeon. She should then superintend the preparation of the operating room; make the gauze sponges, dressings, and bandages; and make up the packages for the sterilizer.

After the room is prepared and the operating furniture is disinfected, everything which is to be sterilized by steam may be sterilized and placed on a table in the operating room.

The water to be sterilized and cooled should be boiled the night preceding the operation and set away in the operating room.

Early in the evening the patient should be given a cathartic, preferably an active saline. If the urine has not already been examined, the nurse should secure a sample, by catheter, if the patient is a female.

Unless the condition of the patient contraindicates it, he should be given a full bath. The abdomen is then shaved, scrubbed with soap and water, and covered by a thick dressing wet in a solution of bichloride of mercury of a strength of 1 to 2000. This pack should be covered by some im-

pervious material like rubber tissue or oiled silk to prevent evaporation. The rubber tissue may be replaced by a piece of oil cloth or oiled paper.

A glass of milk or malted milk may be given the patient at midnight, but no nourishment should be given after that time.

The morning before the operation is a very busy one for the nurse, and she should have the assistance of another nurse or capable assistant if possible. One of these may make the operating room preparation while the other prepares the patient.

The operating room nurse may now sterilize the basins, pitchers, irrigator, etc. Two kettles of hot, sterile water should be reserved for the operation and placed in the operating room. There should also be plenty of hot, sterile water for the use of the surgeon and his assistants, to be used for the cleansing of the hands and for preparing the solutions. This water may be boiled in a large kettle or a clean wash-boiler. A pitcher or basin must be used for dipping the water from the boiler, and must be sterilized outside as well as inside, and when not in use should be placed on a sterilized dinner plate, and not set on any unsterilized surface. The solutions for the disinfection of the hands should be prepared and placed on a table or in a sink in the order in which they are to be used. The concentrated salt solution should be sterilized.

After the arrival of the surgeon the operating room nurse may sterilize the instruments and aid the surgeon in his preparation. She now has her hands partially disinfected by soap and water and

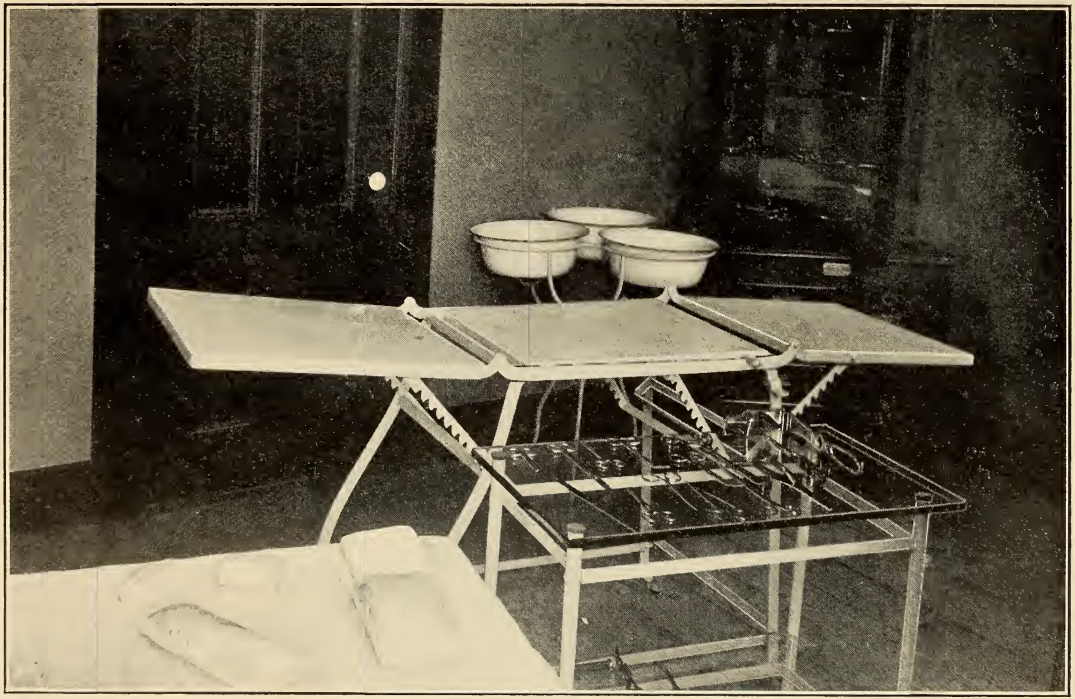


Fig. 42.—Small Private Operating Room, Showing Arrangement of Tables.

bichloride solution, but as she will be obliged to touch many articles which are not sterile, she should avoid contact with all sterile articles.

In opening the sterile packages she should only draw the pins and lay the wrapper open. She should not put the sterile towels on the instrument table. After the patient is brought to the operating room she should remove the abdominal dressing, and bring the solutions to be used in the final preparation of the abdomen.

During the operation she may take charge of the solutions and change the sterile water for sponging, or assist in any other way the surgeon may desire.

While these preparations are being made in the operating room, the patient is being prepared. An hour before the operation he should be given an enema of soap and water, regardless of the action of the cathartic. Just before the etherization is commenced the bladder should be emptied, by catheter if necessary. To avoid all errors, it is best always to employ the catheter. Often the bladder is not completely emptied, and its distension increases the danger of injury to this organ. Some first-class men have also reported errors of diagnosis caused by a distended bladder. The limbs should then be wrapped in a warm blanket, which is well pinned so that it will not become disarranged during the etherization.

If the nurse is competent she may give the anæsthetic, or assist with the sponges or in any other place desired. If the nurse can have no assistance, she will be obliged to divide her time

between the operating room and the patient. In case the surgeon is obliged to operate without the assistance of any trained nurse, he should give explicit directions to some intelligent person for the preparation of the room and general preparation of the patient, and must personally attend to the aseptic preparations, unless he may be fortunate enough to have a trustworthy assistant.

CHAPTER XI.

ORGANIZATION FOR OPERATION.

To do the best work, the surgeon should have assistants who thoroughly understand the principles of aseptic work, and who have had experience in working together, that each may understand his exact duties.

When these may be had, two or three assistants in addition to the anæsthetist are useful. Of these, one may assist at the wound, a second may take charge of the sponges, and the third may attend to the instruments and ligatures.

If thoroughly reliable assistants cannot be obtained, the danger of sepsis is increased in proportion to the number employed. Almost any operation may be performed with a single assistant, and the risk of a slightly prolonged operation is to be preferred to that of sepsis.

The instrument table may be placed within easy reach of the surgeon, while his assistant may both assist him at the wound and may do the sponging. A single assistant is so completely under the observation of the surgeon that an error would be detected, but it would be impossible to watch several.

The surgeon and his assistants should arrive at least half an hour before the operation is to begin. The surgeon should see that nothing has been omitted in the preparation, and that the operating

room furniture is arranged in the way he desires. The operating table should be so placed that neither the operator nor his assistants will stand in his light, and that there shall be plenty of room on all sides.

The surgeon will stand on the right side of the patient, and a table for the instruments and ligatures should be placed on the same side, within easy reach. His first assistant will, of course, stand on the opposite side, and near him should be placed a table for the sterile towels, sponges, and dressings. The bowls of sterile water should also be placed on that side of the table. Another table should be reserved for other sterile articles to be used as required. A chair or table should be placed near the etherizer, upon which may be placed the ether, hypodermic syringe, stimulants, tongue forceps, and mouth-gag. A bowl of solution of bichloride of mercury should be so placed as to be convenient for immersing the hands during the operation.

After the operating room is arranged the surgeon and his assistants disinfect the hands and forearms.

It is a good plan for the surgeon to precede in this work, and for the assistants to follow step by step. In this way each assistant will spend as much time in the process as does the surgeon. The operating suits are now put on, and also the rubber gloves if they are to be worn. The surgeon or one of his assistants may now cover the tables, for the instruments and sponges, with sterile towels, and then may arrange the instruments and ligatures. The glass tubes containing the ligatures are to be

broken by grasping the ends by a sterile towel. After the instruments are arranged, it is well to cover them by a sterile towel until the operation commences, to avoid any possible contamination. While these preparations are being made, the patient is anæsthetized and brought to the operating table. None of the assistants who are to take part in the operation should assist in this.

One of the assistants now makes the final preparation of the patient. If the operation is to be a hysterectomy, or if it is possible that drainage through the vagina will be desirable, it should be disinfected first and then the abdomen. If this assistant is to take any further part in the operation he must sterilize his hands again with the same care that he did at first. Instead of this he may wear rubber gloves while making the preparation and may simply immerse the hands in bichloride solution after their removal.

The body of the patient, excepting the field of operation, and the operating table is now completely covered by sterile sheets and towels.

One sterile sheet reaches from the pubes down over the foot of the table and overhangs at the sides. Another reaches from the neck to the upper limit of the field. At the sides of the abdomen towels are pinned to these sheets. Instead of this arrangement a laparotomy sheet may be used, with an opening in the center.

It is a matter of prime importance that the table should be completely covered. It prevents the unconscious contact of the surgeon and his assistants with unsterilized surfaces and furnishes a

convenient resting place for instruments during the operation.

Should the surgeon be obliged to touch any object which cannot be completely sterilized, as the thermocautery, he may grasp it with a piece of sterile gauze, which must be immediately discarded.

During the operation constant watchfulness is necessary that those who are connected with it shall not contaminate their hands. I am in the habit of requesting my assistants to call my attention to any unconscious act of myself, or of the other assistants, which might endanger the result. When a perfect result, and possibly the safety of the patient is at stake, that which is sometimes called "professional courtesy" should not be fostered.

CHAPTER XII.

PERITONEAL TOILET; SUTURING AND DRESSING THE WOUND.

It is now the purpose to discuss methods of operating only so far as they bear upon the development of sepsis in the wound. Bruised tissues and stagnant fluids, in a wound, favor the development of sepsis, by furnishing a pabulum for whatever germs have gained entrance. Therefore clean incisions, care regarding the bruising of the tissues by retractors and clamps, and perfect hæmostasis are essentials to a good operation.

In cases where a pus-cavity or cyst is present in the abdomen, the danger of infecting the whole peritoneal cavity should be reduced to the minimum by "walling off" the infected area before the abscess or cyst is disturbed, for fear of rupturing it. To wall off the peritoneal cavity properly the intestines should be pressed away from the diseased tissues as far as possible by the fingers, and several thicknesses of sterile gauze packed tightly about the diseased area in every direction. The attempt should then be made to aspirate the septic fluid, to prevent, as much as possible, saturating the gauze.

After the infected tissue has been enucleated or washed out thoroughly the surgeon should cleanse his hands by soap and water and bichloride solution, and any instruments which have been con-

taminated should be discarded or resterilized before the operation continues.

If irrigation is used to wash out the septic material, the nozzle must pass down to the bottom of the cavity, under the guidance of the fingers.

Before the abdomen is closed the cavity should be thoroughly sponged out by dry sponges held in forceps. If a rule is always made never to introduce a sponge into the abdomen unless it is held by forceps, and to leave one end of every piece of gauze used protruding from the wound, there need never be any danger of losing a sponge in the abdomen.

Fluid is most apt to collect in the *cul-de-sac* behind the uterus. To remove this, the body of the uterus should be held forward by two fingers while the sponge is carried down into Douglas's pouch. Care should be taken, in sponging, that the peritoneal surface is not injured by wiping its surface and that the ligatures are not loosened. After the peritoneum is dry all ligatures should be inspected.

If there has been infection and it is desired to employ the postural method of drainage through the peritoneal surfaces, from one to two pints of normal salt solution may be poured into the abdomen.

Before the wound is closed the intestines should be allowed to fall into place and the omentum should be drawn down over them to prevent adhesions to the parietal peritoneum.

Dr. Charles H. Cargile, of Bentonville, Ark., has made use of what he terms "sterilized animal

membrane" for covering areas which cannot be covered with peritoneum, and thus limit the formation of adhesions. This membrane is a very thin gold-beater's skin, made from the peritoneum of the ox. It is asepticized by boiling in cumol, and can be obtained from Johnson & Johnson in the form of folded sheets in a sealed paper package. There would be less danger of its contamination during its preparation, packing, and use if it were sterilized in alcohol in sealed tubes and under pressure.

Dr. Robert T. Morris, who has for many years taught the use of the aristol film over the peritoneal surfaces to prevent adhesions, has used this membrane clinically with success. He has also conducted a number of experiments with rabbits, to determine its utility and the rapidity with which it is absorbed.

As a result of the clinical use and experiments, Dr. Morris concludes that the membrane resists absorption in the abdominal cavity for more than ten and less than thirty days. Its presence apparently causes the formation of temporary loose adhesions, which are harmless and which become absorbed in most part in less than thirty days. The membrane seems to cause very little disturbance to the peritoneum, it does not furnish a good culture medium for bacteria, and it protects areas of peritoneal surface that have suffered injury to their endothelial cells until new endothelial cells have repaired the injury. It is not necessary to suture the membrane in place, as it becomes instantly adherent to moist surfaces, and is not readily dislodged afterward. For this reason it cannot be well handled with wet hands or instruments.

It seems from these experiments that we have in the "sterilized animal membrane" of Dr. Cargile a very valuable resource. In addition to its use for covering in areas which have been denuded of peritoneum it may be used to cover the line of sutures of an intestinal anastomosis, to cover open wounds, and as a protective for skin-grafts.

Suture of the Wound.—The healing of a wound may be much influenced by the method of closing it. To insure immediate union the wound must not only be aseptic, and remain so, but the edges must be accurately sutured.

There is a great diversity of opinion among surgeons regarding the best method of closing abdominal wounds. Many use a suture down through all the tissues into the peritoneal cavity. This *through and through* suture is usually of silk or silkworm gut, and should remain for ten or twelve days. When we were unable to secure reliable absorbable sutures, this method was necessary. When it is not necessary, on account of the condition of the patient, to conclude the operation quickly, the suture of the structures, layer by layer, is much to be preferred. By use of this method all the structures are brought together in their correct anatomical relations. By the use of absorbable sutures through the muscular and tendinous structures, which will resist absorption for twenty or thirty days, the cut surfaces are kept in apposition while the plastic reparative lymph is replaced by normal tissue cells. Most important of all is the shutting off of the peritoneal cavity, should any of the skin sutures become infected. It will be readily seen that stitch

infection may follow down along the suture into the peritoneal cavity if the through and through stitch is used. As the skin nearly always harbors the *staphylococcus epidermidis albus* in its deeper layers, infection may also be carried into the peritoneum as the suture is drawn through in its removal.

If the suture by layers is used, the peritoneum is united by a continuous suture of fine, sterile catgut. The muscular or tendinous structures are then brought together with fine, chromicized catgut. If there is a thick layer of adipose tissue, this should be sutured lightly with sterile catgut to prevent hæmatoma from the oozing. The skin may be sutured with catgut, silk-worm gut, or silk. If catgut is used the continuous suture, or the subcutaneous suture of Halsted, is best.

If catgut is used for the subcutaneous suture, No. 1 plain gut should be selected. The first stitch is made to encircle some of the subcutaneous tissue beyond the angle of the wound, and is tied. The stitch is then passed alternately through the tissue from side to side, and, when the other angle of the wound is reached, the suture is drawn tightly enough to approximate the margins of the wound, and tied. Silk-worm gut is better than catgut for this suture. A strand of large size should be selected. The needle should be introduced one-third or one-half inch beyond the angle of the wound and brought out at the angle. The suture is then introduced in the manner described, but is brought out at the other angle in the same manner as commenced, and the ends are left an inch long and not tied. Silk-worm gut is almost an ideal suture for

the skin. Unless there is great tension, it is only necessary to make the first half of the surgeon's knot. From the stiffness of the material the ends will lie flat against the surface and hold the tissues with only the double twist. If any suture is too tightly or too loosely drawn it may be adjusted at any time. The skin sutures should not include any of the adipose tissue, as this will quickly yield, and in a day or two the sutures will be found loose and the skin margins not in good apposition. On account of the saving of time, the through and through suture must sometimes be used. Silk-worm gut is

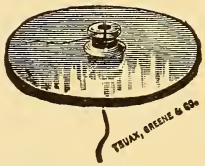


Fig. 43.—Powell's Suture Button.

best for this purpose. It requires some skill and experience so to place the sutures that the tissues shall be brought together in their correct anatomical relations.

The mattress suture is sometimes of use when there is much tension on the sutures. This sometimes occurs in operations for umbilical hernia, or after a large amount of tissue has been removed, as in excision of the breast. It should be of silk-worm gut and should be deeply passed into the tissues, an inch or more from the margins of the wound, and brought out at a corresponding distance on the other side.

The suture should be carried through double, and the looped end cut. The ends should then be secured by a Powell button or they may be passed through the openings of a common agate button, drawn tightly enough to take the tension off the margins of the wound, and tied. Irritation of the skin, from the pressure of the buttons, may be prevented by drawing a piece of gauze under the button. Instead of using the buttons, the sutures may be tied over short pieces of rubber tubing.

Dressing the Wound.—After the sutures are tied the abdomen should be cleansed from blood by washing with sterile water or bichloride solution. It is best first to cleanse the portion about the incision, cover this by a piece of sterile gauze, and then cleanse the remainder of the abdomen. The sponge should never be used on the margins of the sterilized area and then used on the wound.

The incision itself may be covered by rubber tissue to prevent the adhesion of the gauze to the wound. If this is not used, adhesion may be prevented by dusting with aristol. The powder should be poured from a bottle on a pledget of sterile cotton used as a powder puff.

If a drainage tube is used, care must be taken that the dressing does not press too hard on the end of the tube. Should the glass tube be used, it might cause intestinal perforation from the pressure. A large piece of gauze may be laid around the tube in the form of a wreath, and over this the ordinary dressings may be placed.

The dressing should be held in place by two or three strips of rubber adhesive plaster placed

across it and long enough to reach well around upon each flank. When the dressing is to be changed, these strips may be cut in the center and the ends laid back, but not removed from the skin. After the fresh dressing has been applied, the ends of the straps may be fastened together by tapes passed through openings snipped in the ends of the plaster. Over all these the abdominal bandage is tightly pinned, and the patient is transferred to the bed.

CHAPTER XIII.

AFTER-TREATMENT.

The room to which the patient is removed should be heated to a temperature of about 80° F., but should be well ventilated. The bed should be previously warmed by hot-water bottles or by ironing over with a hot flat-iron. The hot bottles should be placed at the patient's feet, and, if there is much depression, should be placed in the axillæ and about the body. Great caution is necessary to avoid burning the patient.

If there has been much loss of blood or depression of the circulation, a pint or more of normal salt solution should be thrown into the rectum. To this may be added whisky or meat extract if desired.

Shock is due in great measure to a temporary paralysis of the vasomotor nerves of the blood-vessels of the abdomen. This allows the vessels to dilate, and a large amount of blood is withdrawn from the general circulation. The best way to combat shock is to fill the vascular system to repletion by some fluid. If the symptoms are urgent the fluid should be introduced into the cellular tissue or into a vein. Venous transfusion will not often be used on account of some of its dangers and the absence of proper apparatus.

A considerable amount of salt solution may

be rapidly introduced into the cellular tissue, and quickly finds its way into the circulation. A large aspirating needle should be connected with the irrigator tube and the fluid slowly injected into some portion of the body where the skin is loose and the cellular tissue abundant. The most favorable place is under the breast. The fluid should be introduced at several points, as too great pressure may endanger the vitality of the tissues and cause a large abscess. At the same time, stimulation of

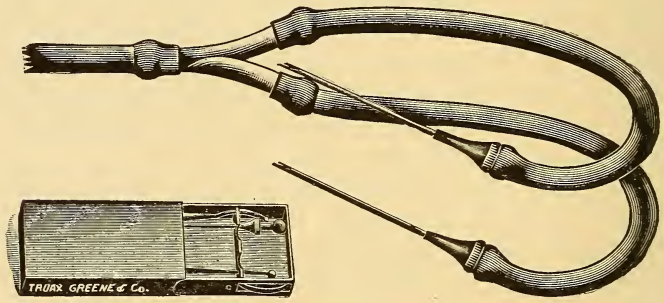


Fig. 44.—Webster's Needles for Hypodermoclysis.

the heart by strychnia hypodermically and whisky by the rectum may be used. If a sufficient quantity of the salt solution is not retained by the rectum, the following stimulating enema may be used:—

℞ Spt. vini Gallici,
Black coffee,
Normal salt solution, of each, 2 ounces.—M.

Excessive Vomiting is very distressing to the patient. The head should be kept low, and when

vomiting occurs it should be turned to the side and a shallow basin should be at hand to receive the vomitus. The nausea usually passes off in from twenty-four to forty-eight hours. Sips of very hot water occasionally relieve it and also the extreme thirst which is always present. If the hot water is rejected, the lips may be wet by means of absorbent cotton wound on a toothpick and wet with cold water. No cold water should be taken into the stomach while the vomiting continues.

Small quantities of iced champagne may be of

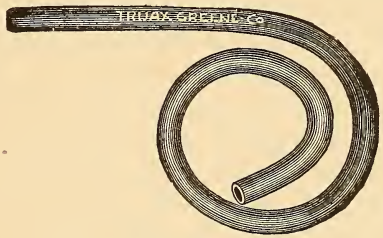


Fig. 45.—Rectal Tube.

benefit. If the nausea is persistent, the patient must be nourished by rectal enemata of beef juice or peptonized milk. If the nausea has subsided after eighteen or twenty-four hours, liquid nourishment—like peptonized or malted milk, egg albumin with brandy, or meat extract—may be given, $^1/_2$ ounce every two hours. In another twenty-four hours milk and lime-water may be allowed, and after the third or fourth day a variety of soft food.

Morphia should be used only when the pain is very severe, since it checks peristalsis and delays

the passing of flatus. It is well to tell the patient before the operation that the pain will be quite severe for a few hours, but will be relieved when he can pass the gas.

I usually promise that he may have morphia if the pain is extreme and appeal to the fortitude of the patient. By this means patients are often seen who do not even ask for it. Much of the pain, after an abdominal section, is due to distension resulting from paresis of the intestines. This may be relieved temporarily by passing a long rubber rectal tube. If this is not successful, the bowel may be stimulated to expel the gas by an injection of 1 ounce of milk of asafœtida and 2 ounces of milk, or by 20 grains of quinine sulphate in 2 ounces of water.

After twenty-four hours the patient should be given a laxative. One or 2 grains of calomel may be given, and followed on the morning of the third day by a Sedlitz powder, in divided doses if the stomach is irritable. If this is not retained or is ineffective, an enema of 1 ounce of magnesium sulphate, dissolved in 5 or 6 ounces of water, may be given slowly through the long rectal tube. The patient should be requested to retain this for an hour or two if possible, and if it has not acted by this time it may be repeated.

The commonly used mixture of Epsom salts, glycerin, and water is not a logical prescription. The glycerin which it contains is intended to stimulate the rectum to immediate action. If it does this, the cathartic effect of the salts is not obtained, as there is no time for absorption. After the

bowels have been moved it is rare for the patient to suffer any considerable amount of pain.

Catheterization after an abdominal section is usually necessary. The secretion of urine is usually much diminished and it is not necessary to use the catheter oftener than once in eight or twelve hours. Extreme care should be used lest the bladder be infected by its use, and it should be abandoned as early as possible.

As soon as the nausea has subsided the patient may be allowed to take the most comfortable position in the bed. It will relieve the backache to be turned toward the side and have the back bathed with tepid alcohol and water. Pillows beneath the knees will relieve some of the tension of the abdominal muscles. The weight of the clothing should be taken from the abdomen and limbs by means of a bed cradle. This may be made by half barrel hoops nailed to a strip of board on each side. Instead of barrel hoops, pieces of strong wire bent like croquet wickets and the ends inserted into holes bored in the side pieces, makes a satisfactory bed cradle.

Removal of Sutures.—If the wound has not been drained it will not be necessary to change the dressing for a week or ten days unless it becomes saturated or the symptoms indicate suppuration. At the first dressing the wound will have become well united, but the union will be weak. One-half of the stitches may be removed if desired, or they may all be left for ten or twelve days. There is nothing to be gained by early removal, and if re-

moved too early the newly formed tissues yield to the traction and a wide scar results.

If the abdominal wall has been closed by layers, the patient may safely sit up in bed by the sixth or seventh day in most cases and sit in a chair at the end of ten days or of two weeks. If the operation has been for hernia, and the patient is very fleshy, or if the incision has been unusually long, he should be kept in bed for another week.

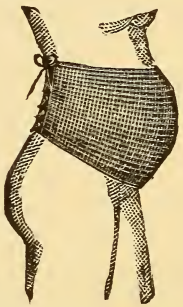


Fig. 46.—Dirigo Abdominal Supporter.

Temperature. — In normal and uncomplicated cases there is always some rise in the temperature, usually to 100° or 101° F. during the second day, gradually subsiding to normal by the third or fourth day, with a very slight rise in the afternoon. If the temperature remains above 100° F. or if after three or four days a chill occurs, followed by a rise in temperature, infection should be suspected and the dressings removed. If any hard or reddened area is found on either side of the wound, the stitch should be removed and the wound slightly pulled

apart at that point to favor the escape of any discharge. It may also be necessary to make a small incision. When a stitch is to be removed on account of a stitch abscess, it should be cut on the side opposite that infected, and traction made on the infected side.

A light abdominal bandage gives comfort and may be worn for several months. One made of elastic webbing and laced in the back is cool, light, and adjustable.

CHAPTER XIV.

VAGINAL OPERATIONS.

Operations about the vagina or rectum can hardly be said to be aseptic operations.

Disinfection of mucous membranes is much more difficult than skin disinfection, and complete asepsis is impossible. The more powerful antiseptics irritate the mucous membrane, and therefore induce conditions which favor the multiplication of those germs which escape destruction. Our principal resource, therefore, in the disinfection of the vaginal canal, must be by thorough cleansing with soap and water and the use of the milder and less irritating antiseptic solutions.

Fortunately the vagina, in the healthy state, is not ordinarily the habitat of the pyogenic organisms.

In 1887 Döderlein investigated the vaginal secretions and found pyogenic bacteria present in $4\,^1/_2$ per cent. of the cases examined. He has been followed by many other investigators, who have had varying results. One class—including Gönner, Krönig, Williams, and Menge—have had almost negative results in regard to pyogenic organisms, while many others have found the staphylococci or streptococci present in from 4 to 27 per cent. of the cases examined.

In view of the great discrepancy in the results of the various investigators, Krönig made

the statement that the positive results obtained by most observers was due to faulty methods of obtaining the vaginal secretion, by which they themselves introduced into the vagina the bacteria which they later found in their cultures.

Krönig's view would seem to be correct, since so many careful bacteriologists have failed to find pyogenic organisms in a large number of examinations.

Previous to this statement of Krönig, Williams, of Baltimore, had found pyogenic organisms in 53 per cent. of his examinations. The vaginal secretion was obtained in these cases by introducing a sterilized, cylindrical, glass speculum into the vagina, and taking the secretion from portions of the vaginal wall which apparently had not come in contact with the end of the speculum. Stimulated by the criticism of Krönig, he examined the vaginal secretion from 92 women, obtained by an apparatus invented by Menge, which obviates all danger of carrying bacteria into the vagina from the vulva. In this series of cases he was unable to cultivate streptococci or staphylococci, with the exception of 2 cases in which the staphylococcus epidermidis albus was present.

The conclusion to be deduced from these investigations is that in cases which have not been recently examined, and in which no disease of the cervix or uterine cavity exists, the vagina may be assumed to be free from pyogenic organisms.

It has also been shown that the normal vaginal secretion is bactericidal, and destroys the streptococcus pyogenes in eleven hours. This teaches us

that our principal efforts in disinfection must be directed toward the vulva and the surrounding region, instead of the vagina. Unfortunately, the external organs of generation cannot be so easily or so certainly disinfected as can the hands. The skin in this situation is plentifully supplied with sebaceous glands, and, from the moisture usually present, this is a site of predilection for bacteria. Nor does the difficulty end when we have disinfected the surface and applied our dressing, but, from the necessary evacuation of the bladder and rectum, it is impossible to keep on a fixed dressing.

For all these reasons operations upon the pelvic viscera should, generally, be done by the abdominal route. Plastic operations upon the perineum, vagina, or cervix, and even a curettement are not so free from danger as is usually supposed.

When an operation by the vaginal route is proposed, an examination should be made several days previous to the operation to determine the existence of any diseased process of the cervix or uterine cavity which would be apt to infect the vagina. Should any evidence of gonorrhœa be found, the operation should be delayed until recovery has occurred. Should there be muco-purulent discharge from the cervix, douches of potassium permanganate in the strength of 1 to 5000 should be ordered twice a day.

In the absence of any diseased condition of the vagina or cervix no douches are necessary.

The intestinal canal, for several days previous to the operation, should be thoroughly cleared by a mild saline laxative each night, and the external

genitals and the buttocks should receive a prolonged bath with soap and water once a day.

The night previous to the operation the patient should be given an active saline. The hair should be shaved from the external genitals as far as the mons veneris, and the vulvar and anal regions thoroughly scrubbed with soap and water, and covered by a napkin saturated in 1 to 2000 solution of mercuric chloride or a 1-per-cent. solution of lysol.

On the morning of the operation the patient should receive an enema of soap and water, at least three hours previous to the operation. If the enema is used later than this, its full action is apt to be delayed, the surgeon is embarrassed, and the result is endangered by the escape, during the operation, of fæcal matter.

After the patient is etherized and brought to the table, the feet and limbs should be protected by the sterilized Canton flannel socks. If these are not at hand, each limb may be wrapped in a sterile sheet.

The surgeon or an assistant must now complete the sterilization of the field of operation so far as possible. For this the rubber gloves should be worn.

First the buttocks and the anal region should be thoroughly scrubbed with soap and water and a gauze sponge. This sponge should be thrown away and the external genitals may then be scrubbed in the same manner, being careful to cleanse all furrows between the labia and about the clitoris.

After this, the surface should be scrubbed for at least five minutes with a solution of bichloride of

mercury 1 to 2000. Should there be any fear of an action of the bowels, the rectum may be packed by a strip of gauze.

The nurse may now remove the gloves from the hands of the operator or assistant and he now proceeds to disinfect the vagina. This should consist, principally, in scrubbing with soap and water. Liquid antiseptic soap, with 10 per cent. of creolin added, may be used, or synol soap may take its place. The vagina should be distended by two fingers of the left hand, and the rugosities smoothed out. The scrubbing may be done by a gauze sponge held in a sponge holder, and should not be so hard as to injure the mucous membrane. Especial care should be bestowed on the cervical canal and the lower part of the vagina near the hymen.

Following this cleansing the vagina should be irrigated with a 1-per-cent. solution of lysol or a solution of permanganate of potassium in the strength of 1 to 5000. After the preparation of the vagina a protector made of two thicknesses of sterile gauze, one yard square, is spread between the thighs, covering all the exposed parts and hanging well down over the buttocks on to the operating pad. The surgeon cuts an opening in this protector, corresponding to the vulva and only large enough to expose the field of operation.

During the operation great care must be exercised lest the hands be allowed to come in contact with some part of the field which has not been completely sterilized.

Vaginal Hysterectomy.—Any contamination from the uterine discharges which are common in this

class of cases may be avoided by packing the uterine and cervical canal with gauze or by grasping the entire cervix with a broad, stout Museaux forceps. This completely closes the cervical canal and serves as a handle by which the uterus may be drawn down and held in any desired position.

Only sterile water or sterile salt solution should be used for irrigation or sponging during the operation.

If clamps are used it will be necessary to pack the vagina with sterile or iodoform gauze, carrying

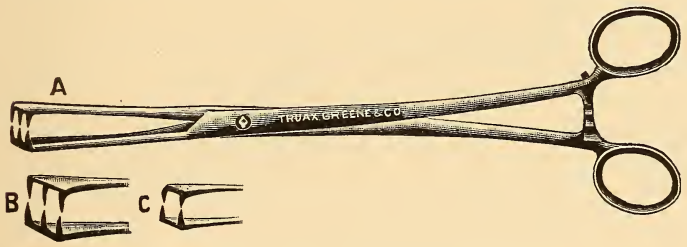


Fig. 47.—Collins's Traction Forceps.

the gauze well over the points of the clamps to prevent injury to the intestines. If ligatures only are used, the vaginal vault should be loosely packed with plain, sterile gauze and the vagina itself with plain or iodoform gauze. This gauze should be removed on the fourth or fifth day and followed in twenty-four hours by douches of sterile salt solution. In using this douche the vulva must first be thoroughly cleansed and then the vulvar orifice held apart by the fingers of the nurse and the tube introduced without touching the external genitals. A backward flow tube should be used and the douche bag should not

be elevated high enough to give much force to the stream, or the newly formed adhesions may be broken up.

Curettement.—After the diseased tissue has been removed by the curette, the interior of the uterus should be irrigated with sterile water. The intra-uterine tube has been sterilized with the rest of the instruments, and when it is to be used the surgeon will hold it in such a way that the nurse may attach to it the rubber piping of the douche bag, without

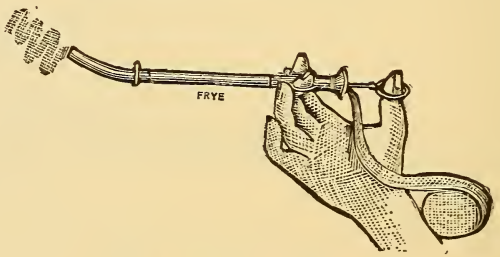


Fig. 48.—Gauze Packer.

permitting the tube to touch her hands or the piping to touch the surgeon's hands. The intra-uterine douche should be used at a temperature of 112° to 115° F., and should be continued until the fluid returns nearly clear. The cavity of the uterus should then be thoroughly dried by sterile absorbent cotton wound on a probe, or by gauze packing. After the uterus is dry its cavity should be swabbed with a mixture of equal parts of liquid carbolic acid, and tincture of iodine. This is applied by means of absorbent cotton tightly wrapped on a uterine sound. The vagina and cervix should be protected from the

escharotic action of the excess, which is pressed from the cotton during its introduction, by packing gauze about the vaginal vault.

The uterine cavity is now packed with a strip of iodoform gauze and the vagina with sterile or iodoform gauze.

These tampons may be removed on the second day and followed by a daily douche as described for vaginal hysterectomy.

Trachelorrhaphy.—Either chromicized catgut or silk-worm gut may be used for repair of the cervix. If a perineorrhaphy is done at the same time, catgut should be preferred for the cervix. The No. 2 chromicized catgut will resist absorption for at least two or three weeks, and that is as long as any sutures are required.

In view of the investigations already mentioned it would seem safer to interdict the use of the douche after repair of the cervix for at least a week. The vulva may be washed with some mild antiseptic solution once or twice a day.

Perineorrhaphy. — The repair of the perineum should cause as much anxiety as any simple abdominal operation.

It is true that infection is not usually so serious in its consequences as when it occurs after laparotomy, but the surgeon has it almost certainly in his power to avoid infection in the latter instance, while in the former, from the situation of the wound, much must be trusted to the competency and faithfulness of the nurse and something to unavoidable contamination during the convalescence.

Should infection occur it is almost sure to nullify

the effects of the operation, and may even lead to a fatal termination. Such a case has occurred in the practice of the author, and numerous other cases have been reported.

If during the introduction of the stitches it is necessary to introduce the finger into the rectum, it should be covered by a rubber finger cot. After the finger is withdrawn, the cot should be removed by the nurse and the hand immersed in bichloride solution for several minutes before the operation proceeds.

After the operation is completed the vagina should be washed out with sterile water and the perineum irrigated or sponged with the same solution. After it is dried with a gauze sponge, the line of sutures should be dusted with aristol, and a sterile vulvar pad, made of gauze and cotton, may be held in place by a T-bandage.

The urine should not be voided, but the patient should be catheterized for at least a week. When the catheter is used the vulva and perineum should be protected by a sterile gauze pad, and the finger should be placed over the outer end of the catheter as it is withdrawn.

The bowels should be moved on the second day, and every day thereafter, by a mild laxative or enema.

Great care must be exercised by the nurse to avoid infection from the fæcal matter. After each movement the patient should be cleansed as much as possible by directing a stream of antiseptic solution from above downward. The cleansing should then be completed by sponging with the same solution,

washing away from the perineum, and on no account touching the wound surface.

The sutures should remain until the wound is firmly united: usually ten or twelve days. The patient should remain in bed for three weeks.

CHAPTER XV.

ARMAMENTARIUM OF THE SURGEON.

THE surgeon who frequently operates away from home will find it convenient to have a stock of gauze sponges, dressings, and other necessaries always prepared and ready to be packed in a trans-

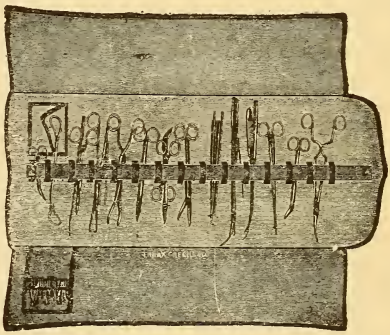


Fig. 49.—Washable Instrument Roll.

portation valise at a moment's notice. The valise should be of large size and should always be supplied with the articles that are generally used in any operation. It should have loops on the side to hold at least six, 4-ounce, large-mouth bottles. These should contain potassium permanganate, oxalic acid, tablets of bichloride of mercury, liquid soap, iodoform, celloidin, and common salt.

The bag should also be stocked with ether, sutures and ligatures, drainage tubes, nail brushes, a Kelly operating pad, fountain syringe, and two or three operating gowns. The dressings, sponges, and instruments may be selected according to the operation and packed into the same valise. The instruments may be conveniently carried in an instrument roll made of Canton flannel or of brown duck. The instruments are held in the loops of a tape running lengthwise of the roll, the edges are

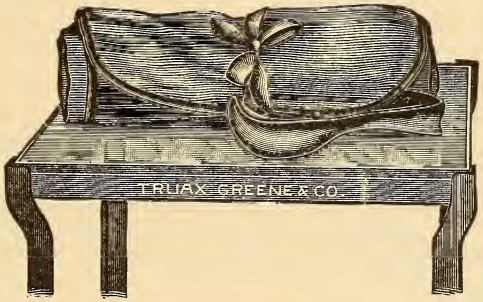


Fig. 50.—Instrument Roll.

turned inward over the ends of the instruments, and the roll is secured by a tape tied about it.

It is well for the surgeon to accustom himself to use as few instruments as possible, and a great number are scarcely ever necessary.

Almost any operation may be done with a scalpel, scissors, hæmostatic forceps, and needles. But special instruments simplify the work and are sometimes absolutely necessary. The ingenuity of the surgeon will often improvise good substitutes for many instruments when necessary.

Instrument lists for the usual operations should be kept and consulted when making the preparation, or the surgeon may sometimes find himself in the embarrassing situation of being ready to do an operation and some such essential article as a scalpel wanting. If some operation is to be done for which the surgeon has no list, he should go through the various steps of the operation mentally and write down each instrument required.

Lists of instruments necessary for various operations are here given. Some of these instruments may be dispensed with or replaced by others. When an abdominal operation is performed it is necessary to have at hand some instruments which probably will not be required, but may be necessary from unexpected conditions.

INSTRUMENTS FOR PERINEORRHAPHY.

Robb's leg holders.
2 shepherd's crook tenacula.
1 scalpel.
2 pair dissecting forceps.
1 pair scissors curved on flat.
1 pair angular scissors.
2 pair sponge forceps.
1 pair needle forceps.
6 large full curve needles.
6 hæmostatic forceps.
1 Sims speculum, or perineal retractor.

Fig. 51.—Shepherd's Crook Tenaculum.

Fig. 52.—Toothed Tissue Forceps.

Fig. 53.—Scalpels.

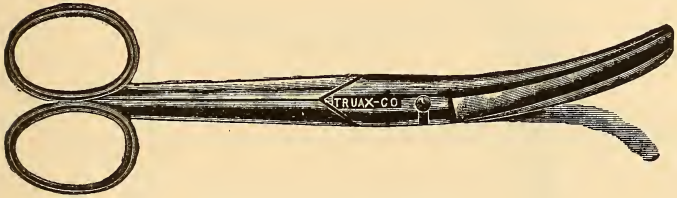


Fig. 54.—Curved Scissors.

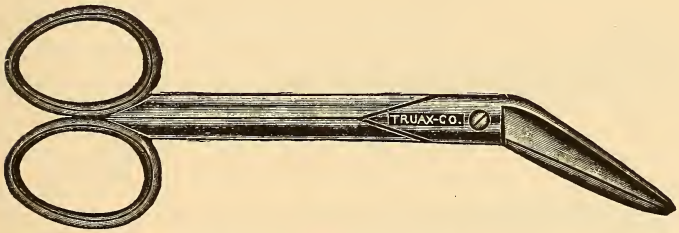


Fig. 55.—Angular Scissors.

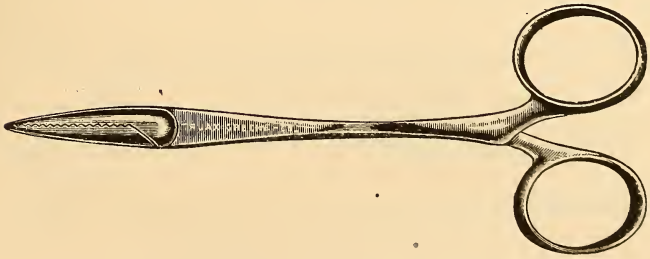


Fig. 56.—Dudley's Hæmostatic Forceps.

INSTRUMENTS FOR CURETTAGE.

Robb's leg holders.
Sims's speculum, or perineal retractor.
Volsellum forceps.
2 pair sponge forceps.
1 pair uterine dressing forceps.
1 strong steel dilator.
2 curettes.
Uterine douche tube.
Uterine sound.

Fig. 57.—Sims's Speculum.

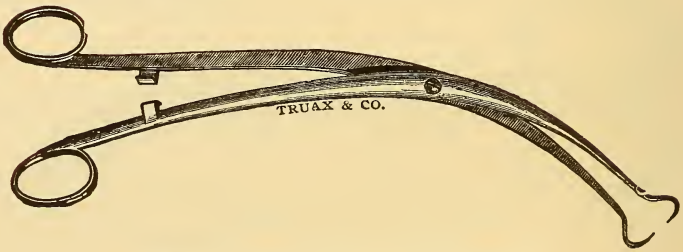


Fig. 58.—Skene's Tenaculum Forceps.

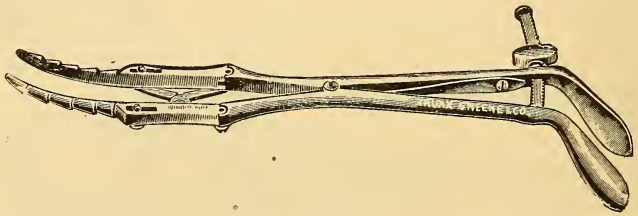


Fig. 59.—Goodell's Uterine Dilator.

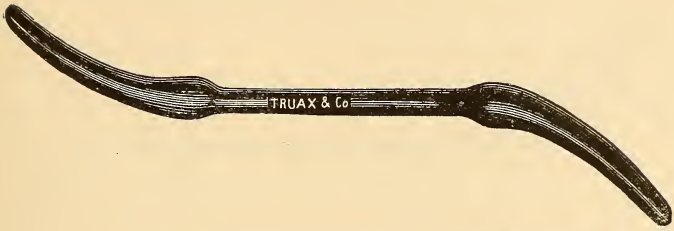


Fig. 60.—Hanks's Conical Uterine Dilator.

Fig. 61.—Kocher's Curettes.

Fig. 62.—Rinsing Curettes.

Fig. 63.—Sims's Sharp Curette.

Fig. 64.—Uterine Curette.

Fig. 65.—Sims's Uterine Sound.

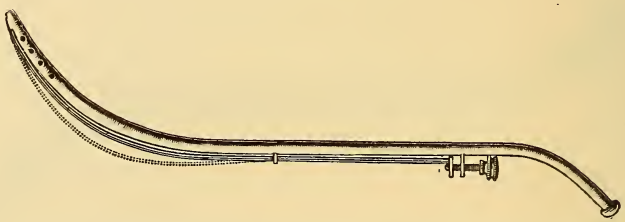


Fig. 66.—Leonard's Dilating Intra-uterine Douche Tube.

INSTRUMENTS FOR APPENDICECTOMY.

1 scalpel.
1 pair scissors.
1 pair large retractors.
1 pair small retractors.
2 pair tissue forceps.
2 pair sponge forceps.
1 grooved director.
1 pair needle forceps.
6 needles.
1 set Murphy buttons.
6 pair hæmostatic forceps.

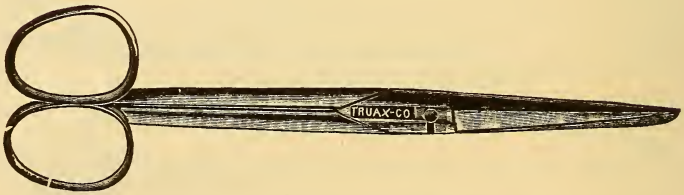


Fig. 67.—Straight Operating Scissors.

Fig. 68.—Volkmann's Sharp Retractor.

Fig. 69.—Grooved Director.

INSTRUMENTS FOR OVARIOTOMY.

1 scalpel.
1 pair straight scissors.
1 pair curved scissors.
1 grooved director.
2 Kelly retractors.
12 pair hæmostatic forceps.
2 pair tissue forceps.
2 pair sponge forceps.
2 hysterectomy clamps.
1 Cleveland ligature carrier.
6 needles.
Aspirator.
Cautery.
Ovarian trocar.

Fig. 70.—Kelly's Retractor.

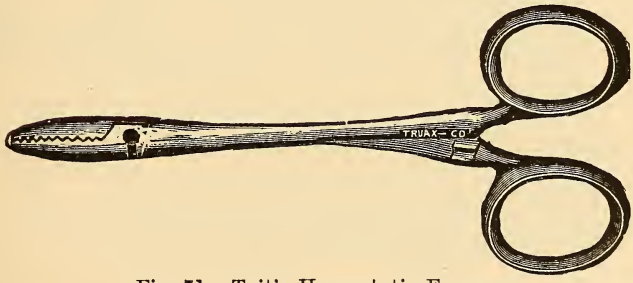


Fig. 71.—Tait's Hæmostatic Forceps.

Fig. 72.—Kocher's Hysterectomy Forceps.

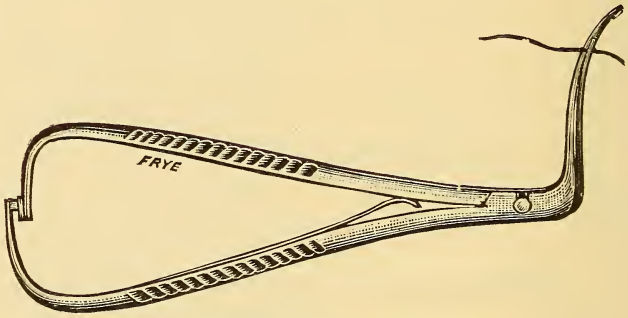


Fig. 73.—Cleveland's Ligature Carrier.

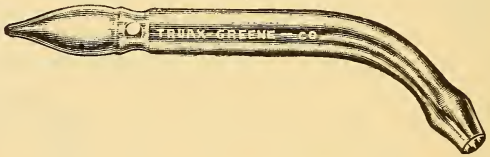


Fig. 74.—Kelly's Glass Ovarian Trocar.

INSTRUMENTS FOR ABDOMINAL HYSTERECTOMY.

2 scalpels.
1 pair straight scissors.
1 pair curved scissors.
1 grooved director.
2 retractors.
12 hæmostatic forceps.
2 pair tissue forceps.
2 pair sponge forceps.
1 pair needle forceps.
1 pair volsellum forceps.
4 hysterectomy clamps.
1 ligature carrier.
1 uterine sound.
1 silver catheter.
6 needles.
Cautery.

Fig. 75.—Transfixion Ligature Carrier.

Fig. 76.—Hysterectomy Forceps.

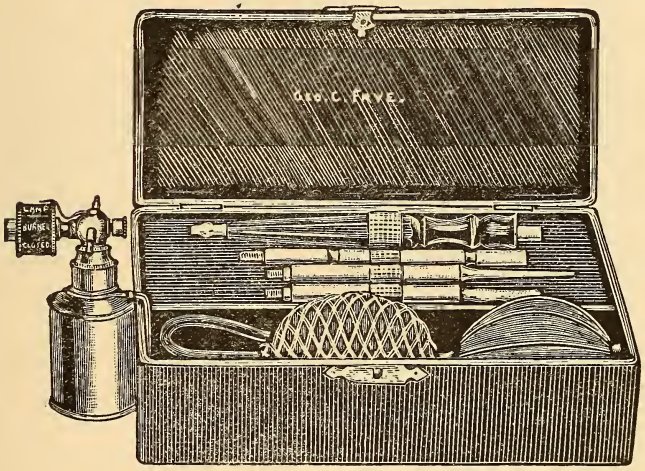


Fig. 77.—Thermocautery.

INSTRUMENTS FOR AMPUTATION.

Tourniquet or Esmarch bandage.
1 large scalpel.
1 pair scissors.
1 amputating knife, or catlin.
1 pair bone forceps.
1 pair needle forceps.
Bone-saw, preferably Satterlee's.
1/2 dozen needles.
6 to 12 hæmostatic forceps.

Fig. 78.—Amputating Knife.

LIST OF ACCESSORIES FOR ANY OPERATION.

Ether.
Sterile sheets.
Operating coats.
Sterile towels.
Gauze sponges.
Dressings.
Nail brushes.
Liquid soap.
Hydrarg. bichloride tablets.
Oxalic acid crystals.
Gutta-percha tissue.
Drainage tubes.
Sterile gauze.
Absorbent cotton.
Celloidin.
Sutures and ligatures.
Kelly's operating pad.
Fountain syringe, or irrigator.
Potassium permanganate crystals.

CHAPTER XVI.

INFECTED WOUNDS.

Wounds may become infected by faulty technique, by operating through infected tissues, or an accidental wound may become infected before it is seen by the surgeon. All infected wounds may lead to serious constitutional disturbances, but the changes in the wound itself will be principally regarded here. The infective agent may be any of the pathogenic organisms, but usually the pus-producing bacteria are present. A wound which has become infected suppurates either in a part or in its entire extent, and heals by granulation.

If a wound has been made by the surgeon through healthy tissues, it may be expected to heal without suppuration, and, if there are no indications of infection, the dressing need not be removed for ten or twelve days. Should the temperature remain above 101° F. for more than forty-eight hours, or if after falling it again rises after the third or fourth day, the dressing should be removed under rigid aseptic precautions and the wound inspected. Should there be redness or swelling about any of the sutures, the infection may be assumed to be a stitch abscess. The stitch should be removed and the wound pulled apart at that point. If it is earlier than the fourth or fifth day it is not probable that any pus has formed, but drainage should be pro-

vided and the wound should be dressed daily thereafter.

Should the wound show no signs of inflammation and if the symptoms are not urgent, the aseptic dressing may be replaced and the patient given a mild cathartic. After the action of this, should the temperature still remain above 101° F. or if chills or restlessness supervene, it may be assumed that there is deep seated infection in the wound, and it must be reopened to its bottom and drainage instituted. An anæsthetic should be given and the wound reopened with the same precautions with which it was originally made, for, if no infection exists, immeasurable harm may have been done if the technique has been faulty, and only slight injury if it has been perfect. Should a suppurating focus be found, the wound should be drained and closed in the manner already described for abscess-cavities.

The dressing for this class of wounds is best made dry, either of sterile gauze or some of the medicated gauzes: iodoform, sublimated, or formalin gauze.

When incisions must be made through tissues which are hard and thickened from inflammatory action, provisional drainage should be used, for suppuration may be expected. If only a limited area of inflammatory tissue is found and if it can be excised, the wound may be safely closed.

This class of wounds do best with a moist antiseptic dressing, covered by some impervious material to prevent evaporation. An excellent moist dressing is made by saturating a compress of sterile gauze of ten or twelve thicknesses in a solution of

aluminum acetate. The standard solution of aluminum acetate contains 8 per cent. of basic aluminum acetate, and this solution should be used in the proportion of 1 part to 15 parts of water. The excess of solution should be squeezed from the gauze, and this should be covered by dry cotton and then by oiled silk or gutta-percha tissue.

If no suppuration has occurred in the wound at the end of three or four days, the drainage should be removed and the wound treated as an aseptic one.

In those extensive areas of wide-spread infection, as in cellulitis of the extremities or in progressive purulent infiltration, the surgical treatment should be the same as for abscesses, only that the incisions should be multiple and should be two or three inches in length that the necrosed tissues may be curetted away and large tubular drains may be inserted.

The drains should traverse the whole extent of the cavity. The tube may be carried into the first incision by means of a curved hæmostatic forceps and a counter-opening made upon the point of the forceps in place where the drainage will be most effective. The cavity may be washed out with the aluminum acetate solution or by iodinized water, prepared by adding tincture of iodine to sterilized water in the proportion of 1 drachm to a quart of water.

A copious moist dressing of solution of aluminum acetate should be applied, and any newly affected area should be treated in the same manner.

Palmar abscesses and suppurative tendo-vaginitis should be treated in the same energetic man-

ner, for both are capable of causing wide-spread destruction of tissue if unchecked.

Suppurative Osteomyelitis.—When suppurative inflammation occurs in the medullary cavity of the bones, it is apt to cause extensive destruction of bone and intense septic infection, unless the pus finds an early exit through the compact layer of bone. As soon as a diagnosis can be made, the canal of the bone should be freely opened by chisel or gouge and the softened and diseased marrow removed with the curette. The cavity should then be as thoroughly disinfected as is possible. This course accomplishes in whole or in part the following results:—

1. It diminishes pain.
2. It lessens destructive necrosis of the bone.
3. It lessens the danger of fatal septicæmia.
4. It enables the surgeon to remove much infected tissue, and thus expedites recovery.

The preliminary preparation is made in the manner usual for other operations. After the diseased medullary tissue has been removed, the cavity should be washed out for five or ten minutes with a 1-per-cent. solution of lysol, and then mopped out with 95-per-cent. carbolic acid on a gauze pledget held in forceps and immediately followed by an application of alcohol. The stronger antiseptic solutions, like mercuric chloride or iodide, should not be used to irrigate the cavity, as from the porous nature of the bone-marrow a dangerous absorption might occur. The same objection holds good against packing a large cavity with iodoform gauze, as is often advised. Either plain sterile gauze

or formalin gauze should be used, and the wound covered by a copious absorbent dressing and placed on a splint. The wound should be dressed daily, and, if the temperature still remains high, the dry dressings may be changed to the dressings saturated with a 1-per-cent. solution of aluminum acetate.

After the acute process has subsided, or in chronic cases in which the pus has found an exit for itself and is followed by necrosis of the bone, the sequestrum and all diseased medullary tissue should

Fig. 79.—Decalcified Bone Chips.

be removed, the cavity disinfected in the manner indicated, and then packed with decalcified bone chips as advised by Dr. Senn. The bone chips are strips of the compact tissue of bone from which the lime salts have been removed, and then the chips are preserved in an alcoholic solution of bichloride of mercury of a strength of 1 to 500. They resemble strips of cartilage, and are probably absorbed in the same manner as catgut. They serve to obliterate the cavity in the bone and act as a scaffolding for the formation of new bone.

The strips should be soaked in sterile water for a short time to remove the solution with which they are saturated. They are then packed in the medullary cavity, level with the surface of the bone. If the periosteum has not been destroyed, it should be stitched with catgut and the overlying soft tissues closed without drainage, and the ordinary aseptic dressing should be applied.

Dr. Senn has obtained unexpected results by this method, and the author has seen a case in which the removal of two-thirds of the medullary tissue of the femur was followed by primary union and no marked change in the contour of the limb.

Should signs of infection occur, an anæsthetic should be given, the wound reopened, the bone chips removed, and the cavity cleansed as before described. The cavity may then be allowed to fill in by granulation, or a second attempt at implantation of bone chips may be made after suppuration has ceased.

Accidental Wounds are always infected. Even if they have escaped infection from the washing and temporary dressing done by the patient or his friends, the object which inflicts the injury is a carrier of bacteria, and the skin is always inhabited by them.

While it has been shown that strong antiseptics have an injurious effect upon injured tissues, yet the damage which may be caused by suppuration is so much greater, that the wound should be thoroughly treated by chemical disinfectants.

The wound should first be covered by some antiseptic gauze, or a towel saturated in bichloride solution, and the surface about the wound should be

thoroughly scrubbed with soap and water and bichloride of mercury solution of the strength of 1 to 1000. This disinfected surface should then be covered by sterile or bichloride towels and the wound itself disinfected. If the wound is an incised one and does not communicate with any cavity of the body, it may probably be disinfected so that union by first intention may be secured.

The wound should be thoroughly cleansed of all particles of dirt, or foreign matter, by forceps and pledgets of cotton. It should then be irrigated for at least ten minutes with a solution of bichloride of mercury in the proportion of 1 to 2000.

If there has been contamination of the wound from street or stable dirt, the disinfection should be doubly thorough, from the liability of tetanic infection. In such a case the wound may be quickly sponged with 95-per-cent. carbolic acid, followed by alcohol. Most incised wounds, if seen by the surgeon within a few hours from the receipt of the injury, may be closed without drainage, with a fair prospect of union. Interrupted silk-worm sutures may be used, and, if signs of infection develop, two or three stitches should be removed at the most dependent part of the wound, and the opening may be kept patent by loosely packing with a strip of iodoform gauze. Instead of completely closing the wound, two or three provisional sutures may be left untied, and a gauze or rubber drain inserted. If no pus has formed after four or five days, the drain may be removed and the sutures tied. Sterile dressings, towels, and sponges are not always available for use in accident surgery, and they are not necessary, as

the treatment must be antiseptic, and not aseptic. If a sterile dressing may be had, the wound may be dusted with aristol and dressed with gauze and cotton. Instead of this, the wound may be covered with a number of thicknesses of iodoform or formalin gauze and this by unsterilized absorbent cotton. The wound need not be inspected for three or four days, and, if no suppuration has taken place, it may remain undisturbed for two days more. If suppuration has not occurred by this time the wound will heal by primary union.

Contused Wounds are almost certain to suppurate, as they must heal by granulation. They should be trimmed of all hanging shreds of skin or muscular tissue, should be cleansed of dirt in the manner described for incised wounds, and, if small, may be disinfected by bichloride solution. If the wound surface is very extensive it is safer to substitute a 1-per-cent. lysol solution for the bichloride, as absorption of the drug may cause constitutional symptoms. The same remark may apply to dressing the wound with iodoform, either in powder or iodoform gauze. After the wound is disinfected as thoroughly as is possible, all parts that may be closed by sutures should be drawn together and supported by adhesive strips which pass over antiseptic gauze placed next to the wound. The wound may be dressed by dusting with aristol, and covering with some antiseptic gauze, preferably formalin gauze. The wound need not be dressed for three or four days, and daily thereafter. Should there be marked inflammatory action and profuse suppuration, the dry dressing may be changed for continuous irrigation with a 1-per-cent.

solution of aluminum acetate. This may be carried out by siphonage of the solution from a large vessel placed above the bed, the solution being conducted into a vessel beside the bed, by a piece of rubber cloth or Kelly pad placed beneath the part irrigated.

Accidental wounds communicating with the cavities of the body are usually either stab or gunshot wounds.

Wounds of the chest, while always dangerous, are not necessarily fatal, unless large blood-vessels are injured. Better results may be expected from simply dressing a penetrating wound of the chest than by operative procedures. The external surface should be prepared in the usual manner, and an antiseptic dressing applied.

Penetrating wounds of the abdomen give entirely different conditions than do those of the chest. If the course of the wound indicates injury to the abdominal contents, the abdomen should be opened regardless of the condition of the patient, unless he is moribund. Should the abdominal contents have escaped injury, the exploration should add no great danger, while, if injury has been inflicted, a fatal result is inevitable unless it can be averted by the art of the surgeon. If an injury of this nature is seen by a physician who is not prepared to open the abdomen, his efforts should be confined to cleansing the parts about the wound in the usual manner, and the application of an antiseptic dressing, until a surgeon can be called.

The earlier the abdomen is opened, the better will be the chance of recovery, and cases are usually fatal unless the operation is done within six or eight

hours after receipt of the injury. Yet it is possible for recovery to follow operation after twenty-four hours. The author has seen recovery follow a gunshot wound of the abdomen, in which the operation was performed twenty-four hours after the injury. The patient was accidentally shot through the abdomen with a rifle ball. The wound of entrance was about two inches to the right, and an inch above, the umbilicus, and the point of exit was an inch above the brim of the pelvis, and three inches to the right of the spine. The wounds had been simply washed with bichloride solution and covered with bichloride gauze.

A mass of omentum, about two inches long, protruded from the wound of entrance. From the course of the bullet it seemed almost certain that the intestinal tract must have been injured. The abdomen was disinfected by the usual method, the protruding omentum was drawn out still farther, ligated, and excised, and then the abdomen was opened. The abdominal cavity contained considerable blood, some liquid fæcal matter, and a fleshy mass four and one-half inches long and one inch wide at its widest part, and tapering at each end. When this was removed it was found to be the lower margin of the liver, which had been completely severed by the bullet.

The injury to the ascending colon was sutured with fine silk, the abdomen was cleansed by dry sponging, and no irrigation was used. The wound was closed without drainage, and the patient made a rapid recovery.

The method which was pursued in this case is

the one to be advised. Should it be impossible to remove all foreign particles, it would be better to use drainage.

This case was treated in an humble farm-house near the Canadian frontier, and well illustrates the possibilities of operative work outside the hospital.

Compound Fractures should always be treated with scrupulous regard for antiseptic details, and the care will be rewarded by the saving of many limbs and an occasional life which would otherwise be sacrificed.

The wound should be covered by a piece of sterile or antiseptic gauze, while the entire limb is scrubbed with soap and water and then with bichloride solution.

The surface about the wound should be shaved and the entire limb enveloped in sterile or moist bichloride towels.

An anæsthetic should now be given. The wound should be disinfected by prolonged irrigation with bichloride solution 1 to 2000, carrying the irrigating point well down into the wound.

The protruding fragment and the wound should be scrupulously cleansed of any foreign matter by forceps and sponging. Should the wound be too small thoroughly to disinfect the deeper parts, it should be freely enlarged, as free drainage is essential in these cases. All loose fragments of bone should be removed, and should the fracture be one which is difficult to retain in place, the ends of the bones should be united by silver wire. Drainage should be established by the use of gauze or rubber tubing, and an aseptic dressing applied. The tem-

porary splint or other dressing may be applied over this. When it is advisable to use a plaster splint, the wound should be covered by a small dry dressing, quadrilateral in shape, and covered by a piece of oiled silk which is wide enough nearly to encircle the limb and is twelve or fourteen inches long. Over this the plaster dressing is applied, and, before it is completely hardened, a fenestrum is cut out over the wound, large enough so that the dressing may be changed.

The oiled silk should now be cut through and reflected back over the four edges of the fenestrum. This prevents the moisture of the dressings from soiling and softening the plaster. The wound should now be treated by the general principles of wound treatment.

CHAPTER XVII.

MINOR ASEPTIC PROCEDURES.

Catheterization.—The use of the catheter is usually necessary after abdominal or plastic operations. Extreme care must be exercised lest the bladder become infected by its use, and it should be dispensed with at the earliest possible time.

The secretion of urine is usually diminished after a surgical operation, and the catheter need not be used oftener than once in eight or twelve hours.

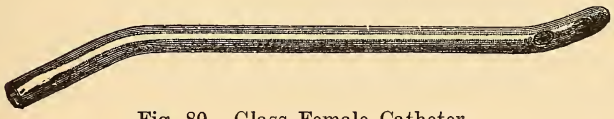


Fig. 80.—Glass Female Catheter.

For females, a glass catheter is best, and should be immediately cleansed after each use, and should be boiled for five minutes just before using again. Soft rubber catheters may be boiled for five minutes, although they are somewhat injured by this treatment. Instead of boiling they may be kept, when not in use, in some antiseptic solution. This solution may be 5-per-cent. carbolic acid, bichloride of mercury 1 to 2000, formalin from 5 to 10 per cent., or 1-per-cent. lysol. The catheter should be removed from the antiseptic solution a few moments

before using and dropped into a basin of sterile water to remove the antiseptic.

For office use a very convenient and efficient method of sterilizing rubber catheters is by means of formaldehyde gas in an apparatus made especially for this purpose. The catheters remain in the apparatus until required for use, and thus kept in an aseptic condition. This method has been considered the only reliable one for the sterilization of elastic web catheters, but Katzenstein has shown that we can depend only on a surface sterilization by this method, and that any germs which are enveloped in masses of mucus in the lumen of the catheter are not reached. It may therefore be said that no method except sterilization by heat is perfectly satisfactory for any kind of catheter.

In the sterilization of elastic web catheters disinfection by antiseptic solutions is of little value, since the germicidal fluid, if sufficiently strong to penetrate to and effectually kill all bacteria, will also serve to disintegrate or destroy the catheter coating. Boiling water softens and destroys the coating of these catheters, and so nearly all careful surgeons have discarded this useful variety of instrument as being incapable of perfect sterilization unless perfectly new.

There have recently been two methods discovered by which elastic web catheters may be boiled many times without injury, and asepsis is thus rendered absolute. The first method was discovered by Herman, who found that elastic web catheters and bougies could be boiled without injury in a saturated solution of ammonium sulphate. A little later

Claudius, of Copenhagen, announced that they can be boiled for long periods without injury in a concentrated solution of common salt, of the strength of 1 drachm to the ounce.

These methods have been tested by Drs. Cotton and Cabot, of Boston, and by the author, and they can be relied on for the sterilization of this form of catheter without injury to it.

Catheterization upon the female may be performed in the following manner: The labia are separated by the thumb and forefinger of the left hand, while the whole vulva is cleansed by pledgets of sterilized cotton, held in dressing forceps and saturated with a solution of bichloride of mercury 1 to 5000. The catheter should now be taken from the receptacle in which it has been boiled, without touching its vesical end, and gently introduced. Before it is withdrawn the outer end should be covered by the finger to prevent dribbling of the urine over the vulva. No lubricant need be used for the female catheter.

For the male, a silver catheter is preferable for the surgeon's use, as it may be repeatedly boiled without injury, and if properly introduced it causes less irritation to the mucous membrane than does the rubber one, on account of its smoother surface. If the catheter must be left for the patient or an untrained attendant to use, the soft rubber or elastic web instrument is safer than one which is rigid.

Catheters with a stylet are not to be recommended for the use of either the surgeon or the patient. Whenever it is impossible to pass an elastic web catheter, a metallic one should be used.

Of all kinds of catheters, only those with a solid end beyond the eye should be purchased. Masses of dirt and mucus are apt to accumulate in this pocket and render asepsis impossible.

A Lubricant is necessary for the male catheter. Vaselin or sweet oil may be very easily sterilized by boiling for five minutes just before using. A preparation called lubrichondrin is an excellent lubricant, which, being free from fats, is readily removed by simple washing. It is preserved in an aseptic state in collapsible tubes, and the portion remaining in the tube is not infected when a part is used. A 50-

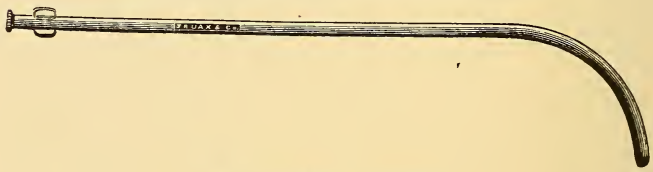


Fig. 81.—Male Catheter.

per-cent. solution of boroglyceride is mildly antiseptic, and is not irritant to the mucous membrane.

If the soft rubber catheter has been kept in a 1-per-cent. lysol solution it may be sufficiently lubricated by this solution.

The distended and diseased bladder which is common with prostatic disease has little power to resist germs which may be introduced during catheterization. The method here described may seem too exacting to be carried out at each catheterization for any long period of time, but its strict observance is the best safeguard against chill following catheterization, urethral fever, cystitis, pyelitis, and

possible infection of the kidney. The passing of a catheter in this condition carries as much responsibility for its aseptic performance as does a major operation. After everything is in readiness to pass the catheter, the penis should be disinfected with soap and water and bichloride solution, and then surrounded by a sterile or bichloride towel. Should there be any urethral discharge, this should be thoroughly washed out with a solution of potassium permanganate, 1 to 5000, or a 1-per-cent. lysol solution. This washing may be done with a small glass nozzle attached to the piping of a fountain syringe. The urethral orifice should be compressed about the tube until the canal is completely filled, and then the fluid should be allowed to escape. This irrigation should continue for at least five minutes.

The hands of the surgeon are now disinfected, the catheter is taken from the receptacle in which it has been boiled or otherwise disinfected, and after being lubricated is passed into the bladder with as little force as possible. If all these precautions are used, catheterization chill and urethral fever, which are merely signs of infection, will be extremely rare.

A patient, who always suffered from chill and fever from catheterization with ordinary cleanliness, was examined thoroughly for stone in the bladder by this method without any such disturbance, although the examination occupied nearly half an hour and several instruments were employed.

It is sometimes necessary, after operations upon the urethra or bladder, to employ drainage of the bladder by a catheter fastened in the urethra for several days. This may be accomplished by tying a

piece of silk around the catheter and fastening these to strips of adhesive plaster passed about the penis. Instead of this an elastic catheter holder may be used.

To prevent infection from following up the lumen of the catheter to the bladder, the catheter should be coupled to a piece of rubber tubing long enough to reach a basin or urinal placed beside the bed and partially filled with some antiseptic solution.

If a graduated glass urinal is used, the amount of urinary secretion may be accurately measured and noted from time to time.

The siphon action may be started in this appa-

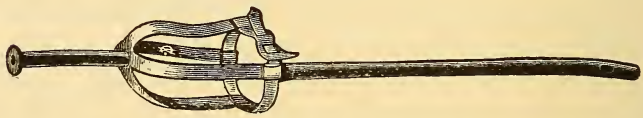


Fig. 82.—Elastic Catheter Holder.

ratus by simply stripping the rubber tubing in a direction toward the receptacle.

Care must be taken, especially after suprapubic cystotomy, that the catheter or tubing does not become occluded by masses of mucus. The nurse should be instructed to measure and record, every hour, the amount of urinary secretion, and, whenever this stops, the tubing should be disconnected from the catheter and suction by means of a small glass syringe should be employed. If the mucus is not dislodged by this manœuvre, a small quantity of sterile water may be forced through the catheter and thus drive the mass back into the bladder.

Bladder Washing is a procedure often necessary in the treatment of cystitis, especially of the chronic form. It is usually effected by irrigating through a catheter, coupled with a fountain syringe or other irrigating apparatus. The same aseptic rules should be observed as in simple catheterization.

The coupling between the irrigator and catheter may be a simple glass or metallic tip, one end of which fits the piping of the irrigating apparatus, and the other end tapered to fit the catheter. If a special tip is not at hand, the glass portion of a medicine

Fig. 83.—Wigmore's Attachment for Bladder Washing.

dropper may be used. After all air has been expelled from the piping by allowing some of the fluid to flow through it, the tip is inserted into the end of the catheter and a small amount of fluid may be allowed to flow into the bladder. Not more than six or eight ounces should be introduced at one time, and the flow should be shut off as soon as any feeling of distension occurs. The tip should now be removed from the catheter and the fluid allowed to flow out. The irrigation may then be repeated until the fluid returns clear.

Instead of using the plain tip, one of the con-

nections made especially for this purpose may be used, and is more convenient. By its use the fluid may be allowed alternately to enter the bladder and to flow out without disconnecting the irrigating pipe from the catheter. These connections are of several patterns, the best known of which is the Wigmore attachment. This is a Y-shaped tube, of which the straight arm forms a connection between the irri-

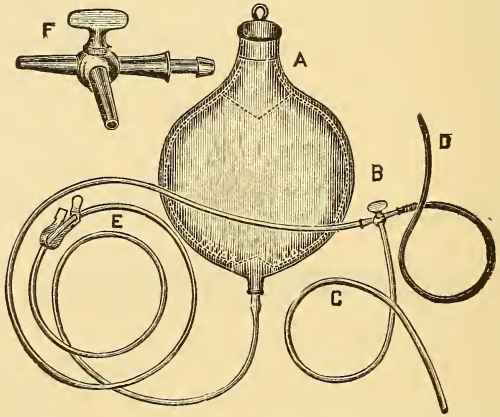


Fig. 84.—Fountain Syringe, Catheter, and Two-Way Stop-cock Prepared for Washing the Bladder.

gating apparatus and catheter, while the branch is the outflow from the bladder. A sliding stop in the main arm controls the inflow and the outflow.

A two-way hard rubber stop-cock may also be used, and the inflow and outflow may be controlled by simply turning the cock.

One of the simplest connections is by means of a soft rubber T-pipe. This is simply a piece of rub-

ber tubing of T-shape with fittings for insertion both into the irrigating pipe and catheter. During the filling of the bladder the lower or dependent portion of the T may be closed by a stop-cock, clamp, or by the fingers. The bladder may be evacuated by closing the tubing connected with the reservoir and opening the escape pipe.

The irrigating fluid will vary with the diseased condition of the bladder and with the views of the physician. No doubt, much of the benefit to be derived from bladder washing results from mechanical removal of the accumulated bacteria and the mucus

Fig. 85.—Soft Rubber T-pipe.

which may act as a culture medium for them. For this purpose, sterile normal salt solution may be recommended, and in many cases this alone can be used on account of the intolerance to any irritating antiseptics. It must be remembered that most conditions for which bladder irrigation would be advised are accompanied by considerable denudation of the mucous membrane, and absorption of poisonous antiseptics must be considered.

In case of an acute cystitis resulting from gonorrhœal infection, the preliminary use of normal salt solution, followed, after the acute symptoms have

subsided, by a solution of permanganate of potash, 1 to 10,000, will give good results.

In cases of chronic cystitis accompanying prostatic enlargement the residual urine should be drawn off with the catheter, once or twice a day, and the bladder irrigated with normal salt solution. It is doubtful if any germs can be destroyed by any antiseptic solution which will be tolerated by the bladder except those which are free upon the surface of the mucous membrane, and these can be removed by the mechanical washing with the salt solution. Should it be decided to use some antiseptic solution, it should be potassium permanganate 1 to 10,000, or boric acid in saturated solution.

Lydston's preference as an antiseptic irrigation is the following:—

℞ Acidi carbolici, 2 ounces.
Sodii biboratis, 4 ounces.
Sodii salicylatis, 2 ounces.
Glycerini, 1 pint.

M. Sig.: Use one-half ounce to each pint of warm water, and add as much boric acid as the solution will dissolve.

In these prostatic cases great care must be used that the bladder be not ruptured by too much distension with the fluid.

Exploratory Puncture is often necessary as a diagnostic measure, and is often followed by aspiration at the same sitting. Thorough aseptic precautions should be used in the preparation of the surface through which the puncture is to be made, and the aspirating needle should be sterilized by boiling. After the instrument is withdrawn the puncture should be sealed by sterile gauze and celloidin.

Hypodermic Injections are so commonly used, and are so rarely followed by abscess or marked inflammation, that very little precaution is used. Yet abscesses occur sufficiently often, and when they do occur they cast such reproach upon the operator that ordinary rules of aseptic work should always be used.

Not only do abscesses sometimes follow hypodermic injections, but the germs of syphilis may be

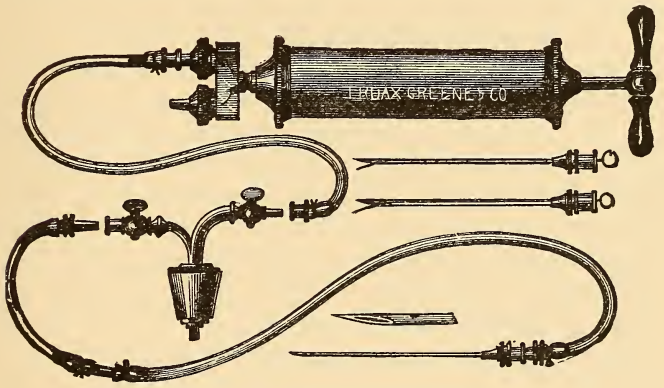


Fig. 86.—Potain's Aspirator.

carried from one patient to another by the hypodermic needle.

For the proper use of the hypodermic syringe, the skin of the patient should be disinfected over a small area, and the needle should be sterilized by boiling or passing through the flame. The barrel of the syringe should be occasionally filled with bichloride solution and after half an hour should be rinsed with sterile water. If a metal syringe with a solid metal plunger is used, the entire syringe may be boiled.

The fluid to be injected is the most important item in the operation. Nearly all drugs for hypodermic use may now be had in tablet form, and are usually carried by the physician. It is only necessary to dissolve the tablet in sterile water to have a sterile solution. A few minims of water may be placed in a teaspoon with the tablet and the water boiled by holding the spoon over a lamp. Should it be necessary to keep a stock solution on hand, the development of bacteria in the solution may be prevented by adding $^1/_2$ of 1 per cent. of carbolic or salicylic acid.

It is sometimes desirable to use some tincture or extract hypodermically instead of one of the alkaloids of the drug. Especially is this true of ergot. Fluid extract of ergot may be used in this manner, but it is quite irritating because of the acids which it contains. Parke, Davis & Co. prepare a fluid extract of ergot especially for hypodermic use, which is free from irritating principles and is kept in an aseptic condition, by hermetically sealing it in glass tubes.

Hypodermoclysis, or the introduction of a large amount of fluid into the cellular tissue, is accompanied by much more danger of local infection and abscess than is the hypodermic injection, on account of the larger amount of fluid and consequently the larger number of bacteria which it may carry, and from the lessened resistance of the tissues from the pressure of the fluid. Extensive abscesses are not uncommon after a hasty and imperfect infusion into the cellular tissue. The most favorable site for the injection is under the breast, on account of the large

amount of loose cellular tissue in that situation. From the small amount of cellular tissue and the firmness of the fascia, the limbs should not be selected for this purpose.

Care must be taken that the salt solution to be used is absolutely sterile and is prepared according to the directions given in a former chapter. The irrigating apparatus should also be thoroughly sterilized as well as the hands of the surgeon and the surface about the proposed site of the puncture.

The breast should be lifted bodily away from the chest wall as the needle is passed into the cellular tissue beneath it.

Care must be taken that the solution is injected into the cellular tissue, and not into the mammary gland.

The fluid will be forced into the tissue slowly, and not more than eight ounces should be injected at any one point. If this amount is introduced under one breast, the needle should then be introduced under the other. After the needle is withdrawn the puncture should be covered by sterile gauze or a celloidin dressing.

CHAPTER XVIII.

CONSTITUTIONAL DISTURBANCES DUE TO WOUNDS AND THEIR INFECTIONS.

WHENEVER traumatism of any extent has been caused, the injury is followed by constitutional reaction. If this reaction is not the result of wound infection, the symptoms rapidly subside.

SIMPLE TRAUMATIC FEVER.

Simple traumatic fever is the systemic reaction which takes place when a wound is healing without the occurrence of infection. In all open wounds there is no certainty that a certain number of germs do not enter the wound, and this fever might be supposed to be due to a toxæmia sufficient to cause a rise in temperature, but not sufficient to cause inflammation or suppuration. But this fever follows simple fractures and internal hæmorrhages, without the communication with any open wound to furnish an atrium for infection. This proves that the process of metabolism going on at the site of injury causes the disturbance. Bergmann attributed it to the fibrin set free at the site of the wound, while Ewald, of Vienna, attributes it to the nucleins.

Tillmans attributes it to the absorption of blood corpuscles and tissue cells which have been destroyed at the site of the wound, and considers that the use of chemical disinfectants augments traumatic fever.

A few hours after an aseptic wound is made the temperature gradually rises to 100° or 101° F. As the rise is gradual, this is not usually accompanied by a chill. The pulse rises to a corresponding degree with the temperature.

The patient suffers very little except from thirst, and after twelve or twenty-four hours the temperature commences to recede and usually reaches normal by the morning of the third day, although slight increase may be noted at night for two or three days more. The diagnosis between traumatic fever and sepsis is principally to be made by the time of its onset. Unless a very gross error has been made in the aseptic technique, by which a sufficient number of bacteria enter the wound to cause an extreme degree of toxæmia, septic fever will not occur in less than four or five days, while traumatic fever will have run its course before that time. So a moderate degree of fever within the first four days need cause little anxiety, while any rise after that time should be viewed with suspicion unless its occurrence is well explained by some other condition. Traumatic fever will be increased by blood-clot or any aseptic tissue which must be absorbed. Therefore the prophylactic treatment is complete hæmostasis and cleansing of the wound, and the avoidance of necrotic tissue in the wound from bruising, the use of antiseptics, or very hot water. The only treatment necessary is frequent cool sponging with alcohol and water, and, if the symptoms are unusually severe, the administration of a saline laxative by the mouth or by enema.

SAPRÆMIA.

Sapræmia is that form of general systemic poisoning caused by putrefactive decomposition of blood-clot or necrosed tissue at the site of the wound. The toxæmia is caused by the entrance into the blood of chemical substances excreted by the bacteria, and not by the entrance into the circulation of the bacteria themselves. Putrefaction is not caused by the pyogenic germs, but by a class of bacteria called saprophytes.

Very often there is a mixed infection, the saprophytes being accompanied by pyogenic bacteria, and then we have both sapræmia and septicæmia.

The symptoms of sapræmia vary with the amount of the dead tissues to be acted on, by the peculiarities of the variety of saprophytes present, and by the rapidity of absorption into the circulation. There is a short period of malaise and headache three or four days after the operation, and this is quickly followed by a sharp rise in temperature and chill. This is often accompanied by vomiting, diarrhœa, and profuse perspiration.

Should the amount of necrosed tissue be small, the saprophytes may exhaust the pabulum and recovery ensue; but it is possible for the system to be overpowered by the ptomaines of putrefaction so rapidly poured into the circulation, and a fatal result may occur in a few hours.

The prophylaxis against sapræmia is careful asepsis and the limitation in the wound of any necrosed tissue or blood-clot which may become infected by putrefactive bacteria. When sapræmia

has actually occurred, the proper treatment is obvious, and if immediately carried out is usually effective. The putrefactive material must be immediately removed from the wound, and this followed by irrigation and drainage.

SEPTIC INTOXICATION.

Septic intoxication is of the same nature as sapræmia, except that the poisonous ptomaines are those elaborated by pus microbes, and not putrefactive saprophytes. It differs from bacteræmia by the fact that the toxæmia is caused by the absorption only of ptomaines, while in bacteræmia the poisoning is caused by access of both ptomaines and bacteria to the circulation. Septic intoxication usually results from an abscess, and the severity of the infection depends upon the absorptive power of the tissues in which the suppuration is located, and the amount of pressure within the abscess.

An abscess with limiting walls within any of the cavities of the body may give very little elevation of temperature or other signs of septic absorption, and it is not uncommon to find a large accumulation of pus in the abdomen with no elevation of temperature or chill to indicate its presence.

The granulation tissue barrier which forms the walls of an abscess does not readily absorb the ptomaines, as was pointed out by Billroth, many years ago, but pressure within the abscess may force the toxins through the barrier or it may rupture it, thus opening up new spaces, giving a chill and rapid rise of temperature.

The treatment of septic intoxication is by the immediate evacuation of the pus, washing the cavity with an antiseptic solution, and the establishment of effective drainage. If no large cavity of the body is infected by this procedure, the temperature and other symptoms rapidly subside after the pressure is removed. If this happy result follows the evacuation of the pus, a positive diagnosis of septic intoxication, and not septicæmia, may be made.

BACTERÆMIA.

Bacteræmia is that form of general infection in which pyogenic organisms are present and multiply in the blood. This occurs both in septicæmia and pyæmia, and, as the two conditions often cannot be differentiated by clinical symptoms, the more general term of bacteræmia may be employed.

SEPTICÆMIA.

Septicæmia is that form of bacteræmia in which some variety of pyogenic bacteria are present in the blood in numbers which render it impossible for the leucocytes to destroy them. Pus microbes in limited numbers may be present in the blood without producing morbid symptoms. To cause septicæmia they must not only be present, but must multiply.

The bacteria usually gain entrance to the blood from some primary focus of suppuration, and may enter the circulation by the lymphatic system or by direct invasion of the blood-vessel walls. Septicæmia is usually a progressive sepsis, because the

essential cause has passed beyond the reach of any local treatment. The intoxication in this form of sepsis is caused not only by ptomaines which are produced at the primary seat of infection, but also by ptomaines produced in the blood by the micro-organisms which it contains.

While the bacteria usually gain entrance to the circulation from some primary suppurating focus, this is not always true, but general septic infection may result from wounds which heal without suppuration.

The symptoms of the disease vary with the rapidity with which the bacteria gain entrance to the circulation, the character of the bacteria, and the resisting power of the patient.

If a large number of pyogenic organisms flood the peritoneal cavity by rupture of an appendical abscess, suppurating gall-bladder, or Fallopian tube, death may result within a few hours from the rapid absorption of the bacteria and their ptomaines.

Septic infection from an accidental or operative wound usually takes place within three or four days. The disease is usually ushered in by a chill, which is followed by febrile reaction and attended by extreme prostration. The patient often has a feeling of well-being, but is stupid and apathetic. The degree of fever may be moderate at the first and gradually increase to 103° or 104° F. This indicates progressive infection by the multiplication of bacteria in the blood.

If the temperature at the onset is high it may be assumed that a part of the symptoms are due to the rapid absorption of ptomaines which were formed

at the primary seat of infection. In other words, the *septicæmia* is complicated by *septic intoxication.*

The most grave cases of septicæmia are characterized by a low temperature, rapid pulse, profuse perspiration, diarrhœa, vomiting, and extreme prostration. Delirium is usually, but not always, present.

Should these symptoms develop, the disease is almost always fatal. A moderate temperature with a pulse not exceeding 120 per minute may justify a better prognosis, but all cases of bacteræmia are always extremely grave, and the less rapidly fatal cases of septicæmia are apt to become pyæmic.

Acute septicæmia may result fatally in a few hours, and is usually fatal within a week from the beginning of the symptoms.

The treatment of septicæmia must rest principally upon disinfection of the primary focus of suppuration, but this is scarcely ever effectual, as the bacteria have passed beyond the reach of the surgeon and are multiplying in the blood. Disinfection of the primary seat of infection will, however, cut off the supply of bacteria from that source, and should always be thoroughly carried out.

All sutures must be removed and every portion of the wound rendered accessible to local treatment. All blood-clots or necrosed tissue should be removed and the wound irrigated with a 1 to 1000 solution of bichloride of mercury. This may be followed, after the wound has been dried, by pure carbolic acid, and this in turn by alcohol. Not more than 1 drachm of pure carbolic acid should be used on the surface of the wound. Honsell, of Tübingen, from a large number of experiments, places the

maximum amount at 6 grammes, or $1\,^1/_2$ drachms. Secondary disinfection of the peritoneal cavity is of little avail when symptoms of septicæmia follow an abdominal operation. It will seldom be undertaken except in those cases in which the symptoms denote a preponderance of sapræmia. In such a case the attempt to remove the infecting agent should always be made.

A number of the sutures at the lower angle of the wound should be removed and the margins of the wound separated. The abdominal cavity should be flushed out with normal salt solution, care being taken that the wound is opened enough to secure a free exit for the fluid.

The end of the rubber tube of the irrigator must be inserted into the deeper portions of the abdominal cavity, especially into the pelvic and the lumbar regions. After the abdominal cavity has become thoroughly cleansed in this manner a large glass drainage tube should be inserted and cared for in the manner already described.

Should there be much peritoneal suppuration and should the condition of the patient warrant it, an anæsthetic should be given, the wound reopened throughout its entire extent, and drainage secured by an incision through Douglas's *cul-de-sac* or through the lumbar region.

Should a localized suppuration be suspected, the wound should be reopened enough to admit the finger, and all adhesions which may inclose collections of pus should be broken down and the abscess-cavity should be washed and drained.

The general treatment of septicæmia consists

in the employment of strychnia and alcohol in large doses and alimentation by all the means at our command. By these aids the leucocytes may be enabled to overcome the invading bacteria in a small percentage of cases of septicæmia.

PYÆMIA.

Pyæmia is that form of bacteræmia in which the bacteria and their ptomaines are not only present in the blood, but also are carried by the blood-stream to widely separated organs and produce secondary suppurating points in those organs. It is septicæmia accompanied by metastatic abscesses.

The name indicates that pus is present in the blood, but it is not necessary that pus corpuscles should be present. The pyogenic bacteria when concentrated at one point set up the suppurative process.

The metastatic abscesses usually result from the breaking up of an infected thrombus. This thrombus forms near the site of the wound and as the coagulum breaks up the emboli are swept into the general circulation, and are arrested by the smaller blood vessels, and from the colonies of bacteria which these emboli carry the secondary abscesses are produced. The infecting organism is usually the staphylococcus pyogenes aureus.

The abscesses are most frequently found in the lungs, kidneys, liver, and spleen. The lymphatic glands are often enlarged, but seldom go on to suppuration.

The location and anatomical structures of the

tissues in which the primary suppuration has occurred have much to do with the occurrence of pyæmia. As the metastatic abscesses which are the distinctive feature of the disease are caused by the impaction in blood-vessels, as emboli, of the pyogenic organisms which are incorporated with fragments of blood-clot or other solid particles, it follows that the primary seat of infection must be at some point where conditions are favorable to the formation of a thrombus.

These conditions are present to a marked degree in the medullary tissue of bone and in the venous sinuses of the uterus. As might be supposed, a large proportion of the cases of pyæmia follow acute osteomyelitis and puerperal infection. Minute thrombi form in small venous radicles at the point of primary infection. After a time these thrombi become softened by the action of the bacteria which have infected them and fragments are swept into the general circulation, bearing with them the pus-producing germs. These emboli become arrested in the minute blood-vessels of distant organs and produce metastatic abscesses at the point of impaction.

The Symptoms of pyæmia seldom develop before the ninth or tenth day after the operation or accident which causes the wound. The onset of the disease is usually rather moderate unless the pyæmia is associated with or results from septicæmia. The fever which accompanies pyæmia is always of an intermittent or remittent type, and is accompanied by frequently recurring chills which mark the development of new foci of infection. Excepting at the onset of the disease, the chills are not usually severe

or prolonged, and are followed by fever with a temperature of 103° or 104° F. for several hours. As the fever subsides, perspiration becomes profuse. The pulse, which at the beginning of the disease is accelerated only during the febrile exacerbations, gradually increases in frequency and diminishes in strength until death ensues.

The usual duration of the disease is from two to four weeks. Death rarely occurs during the first week of the disease, and it may be delayed for four or five weeks. Still more chronic cases with few secondary abscesses may survive for several months.

The Treatment of pyæmia is almost entirely prophylactic: by the strict observance of aseptic rules during the operation and the secondary disinfection of wounds which suppurate, before thrombosis of the neighboring veins occurs.

After the infected emboli gain access to the circulation they are beyond the reach of the surgeon. In those chronic cases characterized by the presence of but few secondary abscesses, these should be opened and drained if their location can be determined.

ERYSIPELAS.

Erysipelas is an acute infectious inflammation of the skin, and in its pure and uncomplicated form this inflammation never causes suppuration or extends deeper than the structures of the skin or mucous membrane. The essential cause of the disease is a streptococcus, from 3 to 4 micromillimeters in diameter, and is identical in its appearance with the

streptococcus pyogenes, except that it is slightly larger. This streptococcus was first discovered by Fehleisen in 1883 and was named by him the *streptococcus erysipelatosis*. With a pure culture of this streptococcus he produced erysipelas in animals, and successful inoculations were also made in man for therapeutic purposes. Of seven persons, the subjects of inoperable tumors, who were inoculated by Fehleisen, six developed typical erysipelas, while the seventh had passed through an attack of the disease only a few weeks previously and was probably protected against a new attack. In some other instances a second inoculation failed after a successful one.

In these inoculation experiments the microbes were found entirely in the lymphatic channels and in the connective tissue spaces, and when a pure culture was used suppuration never occurred. No streptococci can be found in the blood-vessels of the inflamed skin and they appear to be less numerous in close proximity to the blood-vessels.

From the close resemblance of the streptococcus erysipelatosis to the streptococcus pyogenes, bacteriologists have been inclined to regard them as identical, while clinicians have been certain that erysipelas must be caused by a specific germ which, unaccompanied by other organisms, does not produce suppuration.

Since the experiments of Petruschky most bacteriologists consider the identity of these varieties of streptococci to be proven. He obtained a pure culture of streptococci from the pus taken from the peritoneal cavity of a woman who had died from suppurative peritonitis secondary to puerperal para-

metritis. By inoculations with this culture he produced typical erysipelas in two women suffering from cancer. He assumes that inasmuch as he found streptococci present in the pus, and that those streptococci were capable of producing erysipelas, that the streptococcus pyogenes and streptococcus erysipelatosis are identical. This assumption is unwarranted unless it be further proved that every colony from a plate culture produced erysipelas, for, if mixed infection were present, in which both the streptococcus pyogenes and streptococcus of erysipelas were the active agents, the colonies from which he obtained his pure cultures might be the streptococcus erysipelatosis, while the suppuration might be due to the streptococcus pyogenes which could be cultivated from another colony.

The close relationship of erysipelas and puerperal infection has been recognized for a long time by obstetricians. An excellent illustration of this relationship was given in a hospital in which an epidemic of puerperal fever occurred. The puerperal ward was converted into a skin clinic, in which erysipelas promptly appeared.

For this reason it would appear to be possible that the septic peritonitis in Petruschky's case might be due to a mixed infection in which the streptococcus erysipelatosis was associated with some of the pyogenic cocci.

There are most excellent reasons for the belief that the streptococcus pyogenes and that of erysipelas are not identical. As, during the past three or four years, there has been an increasing tendency to regard erysipelas as due to the streptococcus

pyogenes, the subject will be considered at some length.

The reasons for the belief in the non-identity of the streptococcus pyogenes and the streptococcus erysipelatosis are these:—

1. Inoculation with the streptococcus obtained from cases of erysipelas produces erysipelas without suppuration, while inoculation with the streptococcus obtained from pus produces suppuration without dermatitis. Hajek undertook to show that the streptococcus of erysipelas is neither in form nor culture materially different from the streptococcus pyogenes, but in his inoculation of fifty-one rabbits, either cutaneously or subcutaneously, with a pure culture of the streptococcus obtained from a case of erysipelas, the result in every instance was a superficial, migrating dermatitis which resembled to perfection erysipelas in the human subject, while similar injections with the streptococcus of pus produced a more intense and deeply seated inflammation, which in almost every instance terminated in suppuration.

2. Abscesses which show the streptococcus pyogenes in large numbers are not accompanied by erysipelas. Were the streptococcus pyogenes capable of producing erysipelas, the opening of such an abscess would almost certainly be followed by the disease.

3. Erysipelas is a self-limited disease which usually runs its course in one or two weeks, and one attack appears to protect the patient from the disease for a certain length of time. Infection by the streptococcus pyogenes shows no tendency to spon-

taneous recovery or protection against subsequent infection.

4. That cases of erysipelas accompanied by suppuration are cases of mixed infection seems probable from the tendency to metastatic suppuration in those cases. If the non-suppurative cases were due to the same organisms, metastasis would occur in these also.

5. Microscopical examination of the diseased tissue shows a marked difference in the localization of the bacteria. According to Hajek and Fehleisen, the streptococci in cases of erysipelas are found only exceptionally in the immediate vicinity of blood-vessels, while, in streptococcic infection characterized by pus-formation, the streptococci can always be seen arranged in radiate lines around the vessels, entering into the coats of the vessel, and often into its lumen. The streptococci in erysipelas are confined to the lymphatic vessels and connective tissue spaces, while in suppurative inflammation they extend beyond these structures and invade different kinds of tissue.

For these reasons, it seems probable that erysipelas is caused by a specific organism which is so nearly identical in its appearance, growth, and staining properties with the streptococcus pyogenes that it cannot be differentiated by the microscope, but that it produces much different lesions in the tissues of the human subject than does the latter organism.

Erysipelas in all its forms is essentially a wound infection. The cases of so-called idiopathic erysipelas develop from some slight infection atrium. The period of incubation recorded in cases which

have been inoculated for therapeutic purposes ranges from fifteen to sixty-one hours.

The disease usually has a sharp onset, accompanied by a chill, and in a few hours the temperature rises to 103° or 104° F. or more. The fever is continuous, with only slight variations in uncomplicated cases. Simultaneously with the appearance of general symptoms the skin in the immediate vicinity of the infection atrium shows evidence of superficial inflammation. From the point of infection the inflammation spreads continuously by the reproduction of the streptococci. The affected skin presents a characteristic rose or crimson color. This color disappears under pressure, but upon removal of the pressure no depression is left. The induration of the skin is most marked at the margin of the inflammatory zone, and, according to Koch and Fehleisen, the streptococci are always more numerous in this margin than in other portions of the affected area.

The infection has reached its height at the original point of infection at the end of one or two days, and the inflammation subsides here while it extends at the margins of the diseased area. This local subsidence of the inflammation seems to be due to the exhaustion of the pabulum necessary for the growth of the bacteria.

The degree of swelling varies according to the intensity of the infection and the anatomical structure of the part involved. If the infection is mild, and if the skin is tightly stretched over resisting parts, the swelling is much less than if the infection is intense and the affected parts are abundantly supplied with connective tissue.

Often vesicles or bullæ appear. The bullæ are the result of the confluence of a large number of vesicles. The contents of these blisters are serous and contain large numbers of streptococci. Sometimes the contents become purulent by secondary infection by pus microbes.

The duration of an attack of erysipelas is variable, but a typical attack usually lasts from one to two weeks. From the somewhat definite course and the protection which one attack secures against a subsequent one, it seems reasonable to suppose that the streptococci may elaborate an antitoxin which finally destroys the germs, as is the case in diphtheria. When erysipelas appears in an operation wound, it usually occurs within two or three days after the operation or dressing at which infection has taken place. The skin around the wound seems firmer to the touch and presents the characteristic crimson color. If suppuration is present, the purulent discharge becomes diminished in quantity and more serous.

In general, the prognosis of simple, uncomplicated cases of erysipelas is good. Unless it exists as a complication of some extensive wound, it is fatal only in the aged, or by some complication, as secondary infection by pus microbes or by metastatic abscesses.

The course of the disease is very little influenced by treatment. The burning and smarting of the skin may be relieved to some extent by lead and opium wash or by an ointment of ichthyol and lanolin in a strength of 10 per cent. Such measures as injections

of antiseptics at the margin of the disease or painting with tincture of iodine have proved useless.

Powell treats erysipelas with 95-per-cent. carbolic acid and alcohol. With a mop of absorbent cotton he applies the carbolic acid to the skin, and as soon as it turns white he applies alcohol freely to arrest its action. The acid should be applied from half an inch to an inch beyond the margin of the disease. If the diseased surface is extensive, it should be treated in sections. I have never used this method, but it would seem improbable that the staphylococci imbedded in the skin could be destroyed by any means which would not be destructive to the skin also.

Recently a number of cases have been treated by antistreptococcic serum, apparently with good results. This serum is prepared from a mixture of the streptococci from puerperal fever, erysipelas, and pseudodiphtheria, and is intended for use in all these conditions. If the streptococcus of erysipelas is distinct from these other varieties, the disease should be treated with an antitoxin prepared from this alone and unassociated with organisms from other sources. At the present time such an antitoxin has not appeared.

In the treatment of operation wounds complicated by erysipelas, in addition to the measures already indicated free drainage from the wound must be secured if suppuration is present, and a moist antiseptic dressing of lysol or aluminum acetate should be applied. The medicinal treatment of erysipelas should be simply supporting. Large doses of tincture of chloride of iron are usually prescribed,

but should not be used if it disturbs the digestion. Sedatives to control the delirium and nervous disturbance, with supporting doses of quinia, strychnia, and alcohol, should be used.

It is a self-limited disease, the course of which is unaffected by any measures at our command unless it may be an antitoxic serum, which has not as yet been proved.

TETANUS.

Tetanus is a traumatic infectious disease, caused by the entrance, through some wound of the surface or gastro-intestinal tract, of *tetanus bacilli* into the tissues.

These bacilli are especially found in stable excreta, and are common about stables, farm yards, highways, and in garden soil. They are more plentiful in warm climates, and in summer and autumn than at other seasons. They are distinctly anaërobic, or incapable of multiplying in the presence of air or oxygen, although the microbes may retain their vitality for four or five months when exposed to the air, and may multiply as soon as a nutrient medium and the exclusion of air is found. On account of these characteristics, the disease is most likely to develop in punctured wounds, especially of the hands or feet, as wounds of this nature are more exposed to the entrance of dirt from the stable, garden, or street.

The disease is especially liable to result from slight injuries to the hands of children from toy pistols or fire crackers, and every Fourth of July celebration is followed by numerous cases of tetanus.

The disease also frequently follows compound fractures which have been infected by street dust or stable dirt. It seldom occurs as the result of an operation wound, but may follow an abdominal operation, and I have known it to follow an operation for hæmorrhoids by the ligature method.

Within the past two years quite a number of cases of tetanus have been reported, following the use of diphtheria antitoxin and vaccination. Seven deaths followed the use of one lot of antitoxin in Naples, Italy, and twenty cases, with twelve deaths, recently occurred in St. Louis. The St. Louis antitoxin was all taken from the same animal, and he showed signs of tetanus about five weeks after the antitoxin was drawn.

In Camden, N. J., seven fatal cases of tetanus followed vaccination, and four occurred in Cincinnati, Ohio, at about the same time. Whether the virus used was the carrier or whether the germs of tetanus accidentally gained access to the scarified area has been a disputed point. As stable excreta are the normal habitat of the bacillus of tetanus, it seems reasonable to suppose that the virus may have become contaminated either in the pustule or during its removal.

From the investigation of the epidemic in Naples, it was decided that the serum was contaminated after it was drawn. In the St. Louis epidemic it is uncertain whether the germs were present in the circulation of the horse at the time the serum was drawn or whether it became contaminated from faulty technique in its withdrawal. From the length of time that elapsed before the horse developed the

disease it would seem probable that the latter was the case and that the animal was infected at the same time.

It follows that only such serum and virus should be used as has been experimentally tested for the presence of tetanus bacilli before it is sent out from the laboratory.

The Bacillus of Tetanus is a slender rod which presents no characteristic features unless spore-formation has occurred. At body temperature the bacilli develop spores within themselves, which give a characteristic shape, described as the drumstick form. This shape is caused by the round spore which develops at one end of the rod.

The bacilli in which no spores have formed are destroyed by the ordinary means of steam sterilization, but the spores are very resistant and require fractional sterilization for their destruction.

The development of tetanus is rather retarded than favored by suppuration in the wound. The wound has usually healed promptly, but a minute abscess may be found at its bottom.

The bacilli of tetanus have rarely been found in the blood or in tissues remote from the primary entrance of the germs. The symptoms seem to be due to toxins which are formed by the bacilli in the tissues near the infection atrium, and, after being taken into the circulation, they act on the central nervous system much as does strychnia. Kitasato, who has studied the disease artificially produced in animals, reports that the spasms first begin in the muscles nearest the site of inoculation. This shows that the toxins which are formed near that point act

upon the terminal nerve-fibers before they gain access to the circulation in sufficient quantity to act on the central nervous system.

Acute tetanus usually develops in about one week after the receipt of the injury, although the period of incubation is considerably influenced by the number of bacilli introduced, the presence of dirt or other foreign bodies in the wound, and the character of the tissues involved.

The first symptoms usually are stiffness of the muscles of the jaw, then of the back of the neck, and in a few hours all the muscles of the back are affected. At first there is only stiffness and some pain upon motion, but this is rapidly followed by violent spasm of the muscles of the body and lower extremities. Owing to the spasm of the sphincters, voluntary movements of the bowels and bladder are very difficult.

The mind usually remains clear throughout the course of the disease, and the temperature is not usually much elevated, but near the close there may be hyperpyrexia. The pulse increases in rapidity steadily as the exhaustion from the convulsions increases. The disease usually results fatally within a week from its onset, and may do so within a few hours. The disease occasionally takes a more chronic and milder course. In these cases the symptoms do not usually make their appearance until the third or fourth week, and recoveries are not unusual. The cases which have this favorable termination may be accompanied by severe spasms, but there are periods during which the patient experiences relief from the muscular contractions. These periods

gradually become longer and finally the contractions disappear.

The prognosis in the acute form is exceedingly grave, while a fair percentage of the chronic cases end in recovery.

Generally, the longer the period of incubation, the more probable is the recovery of the patient. The possible explanation of this fact may be that but a small number of bacilli enter the wound, and that during the time that the germs are multiplying to the extent that they can cause symptoms, the patient is becoming immunized to their action, in the same way that animals are immunized by successive inoculations with progressively increasing doses of the living cultures.

Treatment. — The prophylaxis consists in strict attention to the details of asepsis, and the thorough disinfection of punctured wounds of the hands or feet, especially if they have come in contact with street dirt, garden soil, or stable dressing.

If a wound has occurred under these circumstances, it should be enlarged to a sufficient size for its thorough cleansing by water, and this should be followed by pure carbolic acid and alcohol. Free drainage by gauze should be established, as it is only in closed wounds that tetanus may be expected to develop.

After the disease has developed, local disinfection of the original wound is of the greatest service. It is in this immediate vicinity that a great part of the germs are located. The wound should be reopened to its bottom, and, if possible, the tissues in its immediate vicinity should be excised. The wound

should then have a prolonged irrigation with a solution of bichloride of mercury or should be treated with carbolic acid and alcohol.

Several cases have been reported in which an immediate improvement followed this plan of treatment, and Senn reported the remarkable recovery of a patient in whom tetanus followed an operation for acute osteomyelitis. Immediate improvement followed the secondary disinfection of the wound, and the patient finally recovered.

Chloral Hydrate seems to be the most efficacious drug in the treatment of the disease. In very large doses it will relieve the muscular spasm, but it does not seem to lessen the mortality. *Chloroform* and morphia are the only other drugs which are of service, and these only palliate the symptoms.

Serum-therapy. — The treatment of tetanus by the injection of the serum of animals rendered immune by repeated inoculation has been practiced to quite an extent during the past five or six years, but with no very marked success.

The injection of the serum of an immunized animal will protect another animal from developing the disease if the injection is made prior to the infection. The serum can also modify the disease and prevent a fatal result if it is injected at the time of infection or very soon after. Its efficacy is in inverse ratio to the time which has elapsed after infection before the serum is used. If used only after the symptoms have fully manifested themselves, it seems to have little effect.

Recently injection of the serum into the brain substance has been practiced, apparently with better

results. The injection is made into one of the frontal lobes, through a small hole in the frontal bone made by a bone-drill. Such radical measures are advisable, should further experience prove that the intracerebral injections are more efficacious than the subcutaneous or intravenous use.

If the serum is used only after tetanic symptoms have appeared, relatively large doses will be required, and the amount required rapidly increases according to the length of time the disease has existed. Taking Behring's serum as a standard, 100 cubic centimeters of the serum should be injected during the first twenty-four hours in a well-developed case, and two or three times this amount would be required for a case in which the well-marked symptoms had existed for two or three days.

At the present time the serum must be regarded principally as a protection against the disease, and, after it has developed, as an adjuvant to the other methods of treatment, of which disinfection of the primary seat of the disease is the most important.

CHAPTER XIX.

ASEPTIC MIDWIFERY.

EVERY puerperal woman is a surgical patient, inasmuch as there is always a trauma at the placental site, and usually at the cervix or perineum also. Most of the pathological conditions following labor are due to infection of these wound surfaces during labor or subsequently.

The mortality from puerperal sepsis has greatly diminished during the past decade, but it is not yet unknown to us.

It has already become known to the laity that childbed fever is not due to "taking cold," but is due to infection, and its occurrence casts reproach upon the physician or the nurse or both.

For many reasons the country physician is often unable to conduct a perfectly aseptic labor. Often his first knowledge of the case is a hurried call into the country, where he may find the patient well advanced in labor, possibly on an unclean bed, and attended by a nurse who knows nothing whatever of asepsis even if she does of cleanliness.

The correction of this condition rests with the physician, who should always explain the dangers of such a course. But more difficult than the attainment of surgical cleanliness during the labor is the task of keeping the parturient canal free from germs during the convalescence.

Advice to the family regarding a nurse is often a delicate subject. Only exceptionally is this advice sought, and often some acquaintance or friend of the family who occasionally nurses obstetric cases has been engaged before the physician is consulted. It is even more necessary that the obstetric nurse should understand the principles of asepsis than that the surgical nurse should. After an abdominal section the surgeon may cover the wound by a dressing which excludes all germs, but this cannot be done with the puerperal patient, and much depends upon the conscientious after-care by the nurse.

Upon proper occasions the physician should instruct his patients in this respect, and should always endeavor to impress the most essential part of the aseptic technique upon whatever nurse may be forced upon him.

But there are many physicians who are themselves guilty of culpable neglect in respect to aseptic precautions. They would make much more elaborate preparation for a slight surgical operation, yet sepsis following the amputation of a limb would be much less serious than that following a delivery.

When the physician is engaged to attend an obstetric case, he should attempt to have a reliable nurse employed also, and he should have the patient under observation for the last few months of pregnancy.

THE PATIENT'S OUTFIT.

Some time previous to the expected time of confinement the physician should give the patient a list of the articles to be provided by her. These

articles are to be used by the nurse before the arrival of the physician.

They should be in readiness three or four weeks before the expected date of labor, and should be as follows:—

1 dozen towels.
1 new nail brush.
4 ounces antiseptic or tr. green soap.
4 ounces lysol.
1 pint alcohol.
25 tablets of mercuric chloride.
1/2 pound of absorbent cotton.
Safety pins of various sizes.

An Obstetric Pad, to be placed under the patient's hips after confinement, is restful to her, and protects the bed from soiling by the lochia. It is made one yard square, by quilting a layer of ordinary cotton batting between two layers of cheese cloth.

Sanitary, or Vulvar, Pads are made by covering with plain absorbent gauze a rectangular piece of absorbent cotton, ten inches long, three or four inches wide, and two inches thick. Two or three dozen of these pads should be made. If it is necessary to economize, these pads may be replaced by the usual linen or cotton napkins.

Two Pieces of Rubber Sheeting are convenient for preparing the bed. These should be one yard wide and one and one-half to two yards in length. They may be of the cheap enameled cloth, although the rubber sheeting is more flexible and to be preferred on that account. If these are not provided, the bed may be protected by spreading several layers of newspapers between the other coverings.

Abdominal Bandages are best made from very thin outing flannel, and may be made in the same

manner as the surgical binder. Four or six bandages should be made.

Three or four wash-basins and two toilet pitchers will be needed, as well as a slop jar.

Beside the dozen towels mentioned as being put aside, an abundant supply of clean towels, sheets, night gowns, and undervests should be in readiness.

A Fountain Syringe should always be included in this list, and should be new or nearly so.

THE PHYSICIAN'S OUTFIT.

The physician's obstetric bag should be supplied with not only the articles which he will need in addition to those included in the list given the patient, but he must be prepared for a case in which these articles have not been secured.

The following is a good list of articles with which it may be stocked, but the list may be changed to suit the fancy and requirements of the physician:—

Silver or glass catheter.
Obstetric forceps.
Straight scissors.
Intra-uterine douche tube.
6 pair hæmostatic forceps.
Ashton's or Peaslee's perineum needle.
6 curved needles with large eye.
Needle forceps.
Catgut and silk-worm gut sutures.
Bobbin thread or tape for the cord.
1/2 dozen rubber finger cots.
1 pair rubber gloves.
1 rubber apron or gown.
Kelly pad.
Fountain syringe.
Antiseptic soap or tr. green soap.
Corrosive sublimate tablets.
Nail brushes.
Lysol.
1 tube lubrichondrin.
1/2 dozen sterile towels.
1/2 dozen sterile vulvar pads.
1 dozen sterile gauze sponges.
1/2 pound absorbent cotton.
Chloroform.
Ether.

Such an outfit as the above includes everything which would probably be needed in an ordinary labor, and the list may be reduced by one-half and still contain the articles usually required.

PREPARATION OF THE ROOM.

At the onset of labor the nurse should notify the physician and then prepare the room and the patient.

The lying-in room should be large, airy, and sunny. All superfluous furniture and draperies should be removed. The necessary furnishings are

Fig. 87.—Ashton's Perineal Needle.

a bed, one or two tables, a wash-stand, and necessary chairs.

The Bed should be prepared in such a way that the soiled clothing beneath the patient may be easily removed after the labor is terminated, leaving the patient on a dry bed.

The mattress should be covered by one of the pieces of rubber cloth, and this by a folded draw sheet. These should be pinned to the edges of the mattress, and over them should be a sheet. This makes the bed as it is to be occupied by the patient after delivery.

The temporary coverings, to be removed after labor is completed, consist of a second rubber sheet covered by a folded white sheet. These are also

securely pinned to the sides of the mattress. Before the conclusion of the first stage of labor a Kelly pad should be placed under the patient's hips, and the apron so placed as to convey the fluids into a slop jar placed beside the bed.

Fig. 88.—Kelly's Cervical Needle.

At the earliest indications of labor the nurse should sterilize some water to be set away to cool, and should also sterilize the dozen towels in two packages, and one dozen of the vulvar pads, each of which is wrapped separately in cotton cloth. If no sterilizer can be had, these may be sterilized in a clean cooker or wash-boiler in the manner previously described.

PREPARATION OF THE PATIENT.

The first step in the preparation of the patient should be the administration of a copious enema of

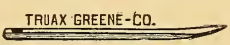


Fig. 89.—Palmer's Cervical Needle.

soap and water. She should then be given a full bath, either by sponging or in a bath-tub if the pains are not too active. After this she is attired in fresh

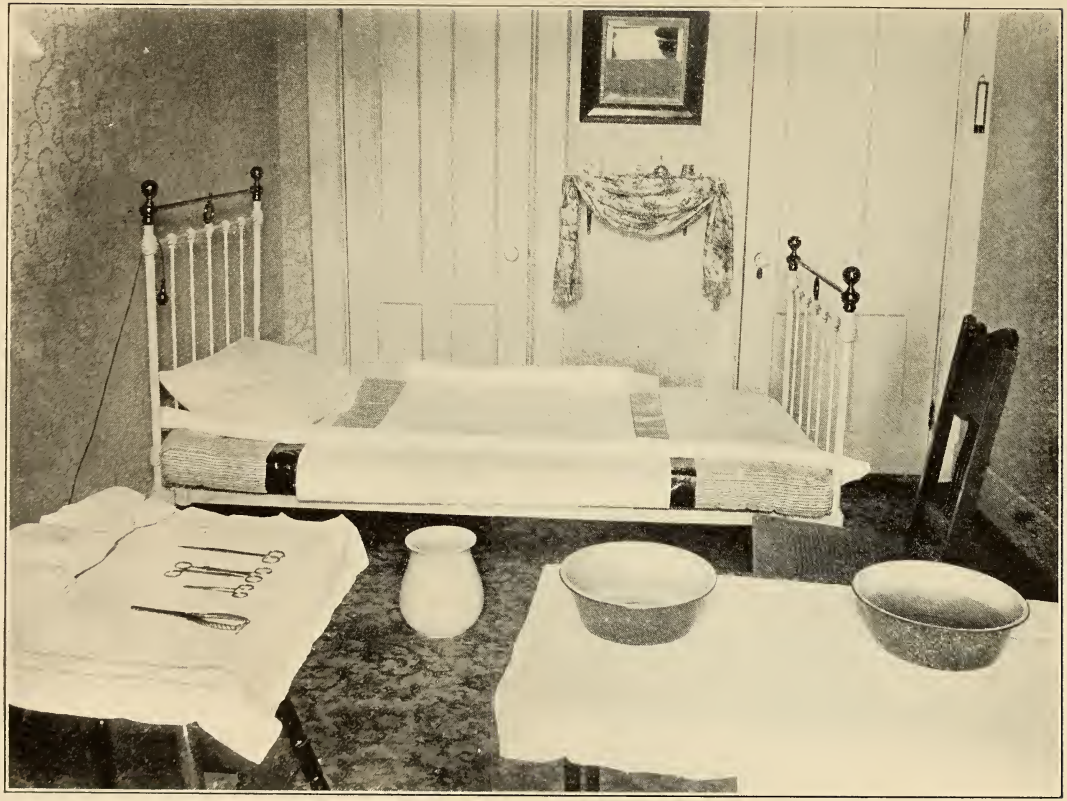


Fig. 90.—Room in Private House Arranged for Labor, Showing Manner of Preparing the Bed.

clothing, and, if comfortable enough to be up, she may have a loose wrapper or bath robe over the night gown.

After the arrival of the physician, but before an examination is made, the external genitals should be disinfected. The hair on the labia should be clipped off with scissors, and then the external surface of the labia, the perineum, and buttocks should be washed with soap and water and bichloride solution in a strength of 1 to 2000. After this the vulva should be carefully cleansed with 1 to 4000 bichloride solution or a 1-per-cent. lysol solution.

The Ante-partum Douche has been the subject of much discussion in years past, but it has been abandoned by nearly all obstetricians, unless the patient shows infection of the vagina or cervix. From the investigations of Döderlein, Krönig, and Williams, which have been mentioned in the chapter on vaginal operations, it seems to be proved that the vagina and cervix do not usually contain pyogenic cocci, unless as a result of gonorrhœal infection. As infection must come from without, it is unnecessary to disinfect the vagina unless there are signs of gonorrhœa, and any antiseptics capable of destroying pus-germs are injurious to the epithelial layer of the vaginal mucous membrane.

Our efforts at securing asepsis should consist in a thorough disinfection of the examining hand, and of the parts with which it will come in contact before entering the vagina. After the disinfection of the external genitals the vulva should be covered with a sterile pad, or, in the absence of this, by a napkin soaked in a 1 to 1000 solution of mercuric

chloride wrung as dry as possible. Should an evacuation of the bowels occur after this, the disinfection should be repeated.

CONDUCT OF LABOR.

Soon after the arrival of the physician he will make an examination to determine the position and to detect any abnormalities of the fœtus or parturient canal. After this initial examination they should be very infrequent, and in a normal case no other examination is necessary during the first stage. Many obstetricians determine the position of the fœtus by abdominal palpation, and abandon the vaginal examinations. The position of the fœtus is only one of the many things which a vaginal examination reveals, and if done in a proper manner there should be no danger of infecting the patient.

After the nurse has prepared the patient in the manner already described, the physician should sterilize his hands in the manner described for a surgical operation. Unless he has been in attendance on some septic case, the Fürbringer method, by means of soap and water and bichloride solution, is all that is necessary.

Should he recently have seen any contagious or septic case, he should disinfect the hands by the potassium permanganate and oxalic acid method. A still better plan in such a case is to wear the sterile rubber gloves. The rubber gloves interfere to some extent with the tactile sense, but they should always be worn if the physician has recently examined a case of puerperal septicæmia or is in attendance on

a case of erysipelas or phlegmonous inflammation. Usually no lubricant is needed in making the examination, but, should it be desired, the hands may be immersed in a 2-per-cent. lysol solution, which is both antiseptic and lubricant, or freshly sterilized vaselin or lubrichondrin may be used.

After the physician's hands have been sterilized the nurse removes the sterile vulvar pad, and raises the sheet which covers the patient in such a way that the physician can see the vulva, taking care that the clothing shall not come in contact with his hands. The physician, with the fingers of the left hand, separates the labia as widely as possible, while the examining finger is passed into the vagina without coming into contact with the external genitals. The left hand may now be used over the abdomen for bimanual palpation, but it should not be forgotten that it is no longer aseptic.

This same method of hand disinfection should precede every examination during the labor.

At the commencement of the second stage the nurse should prepare a large toilet pitcher full of bichloride solution 1 to 2000, and two quarts of a 2-per-cent. lysol solution, using sterile water at a temperature of 110° to 115° F. The few necessary instruments—as the catheter, scissors, and douche tube—should be sterilized by boiling at the same time.

On one table may be placed the sterile instruments, sponges, towels, and vulvar dressings, while on another may be placed the solutions.

The Kelly pad, which has been placed under the hips of the patient before the conclusion of the

first stage, is covered by a large sterile towel or one which has been wrung out of bichloride solution.

During the second stage the examinations must be more frequently made, and, if the physician avoids handling unsterile objects, the thorough scrubbing with soap and water may be omitted before each examination, but the hands should always be immersed in the bichloride solution for two or three minutes. To avoid contamination from contact of the hands with his own clothing it is well for the physician to wear a sterile gown, which he may carry in his obstetric bag, having been previously sterilized.

As soon as the head has descended sufficiently to distend the perineum, the attention of the physician should be constant, for the protection of this structure, and the vulva and adjacent parts should be frequently cleansed by means of a sponge wet in the bichloride or lysol solution.

Should any of the contents of the rectum be expelled during the pains, the nurse must immediately cleanse the surface, by sponging away from the vulva toward the sacrum. Should the physician's hands come in contact with the fæcal matter, they must be scrupulously disinfected before proceeding further. Should the towel under the hips of the patient become soiled, it must be immediately replaced by a fresh one. Should the physician consider it necessary to introduce the finger into the rectum for the protection of the perineum, it should be covered by a rubber finger cot.

After the delivery of the child the placenta should be removed by expression, except in case of alarming hæmorrhage or the rare condition in which

the attachment of the placenta to the uterus is so firm that it cannot be removed by the Credé method. In these instances it may be necessary to pass the hand into the uterus, but this must never be done except in the greatest emergency and under the most rigid aseptic details.

The nurse should provide some receptacle for the placenta. A shallow tray or basin is the best. It may be covered by a bichloride towel and the tray may be held closely against the left buttock of the patient, so as to receive the placenta as well as the gush of blood and clots which follow its expulsion.

The vulva and surrounding parts should now be cleansed by the physician, as his hands alone are aseptic. This cleansing may be done by sponging with some antiseptic fluid or by irrigation with the fountain syringe. The sponging should first be confined to the vulva, and last the surrounding tissues. After this is completed a sterile vulvar pad should be applied, the Kelly pad and the temporary coverings of the bed should be removed, and the obstetric pad placed under the hips of the patient.

The binder may now be applied, and, if by any chance the patient's clothing has become soiled, they should be changed.

EMERGENCY CASES.

The physician will often be called under such circumstances that the method here advised cannot be fully carried out, but the cardinal principle—that an examination should never be made until the hands of the physician and the genitals of the pa-

tient have been disinfected—may always be insisted upon. Should the delivery be so nearly completed that this cannot be done, the only assistance the patient will require will be the support of the perineum, and no vaginal examination is necessary.

If sterile towels and napkins for the patient cannot be obtained, a temporary vulvar dressing which has been wrung from bichloride solution may be used until the vulvar pads or napkins may be sterilized by steam.

The old method of saturating the napkin in alcohol had some merit as a disinfectant, and not by preventing the patient from taking cold, as was formerly believed.

INSTRUMENTAL LABORS.

Whenever it is necessary to employ instruments in any way during the labor, surgical asepsis must be strictly followed. If this is done the danger of infection is not increased by instrumental interference, and an intelligently conducted forceps delivery is less likely to be followed by sepsis than is a prolonged labor, during which the tissues have been injured by the long continued pressure of the fœtal head, and are rendered less resistant to the bacteria which may be carried into the vagina by the repeated examinations, despite the utmost care of the accoucheur.

Usually the patient should be anæsthetized when any instrumental interference is necessary, and should be placed in the dorsal position. This position may be maintained best by the gynæcological

operating strap or by an assistant holding each limb. Whatever instruments will be required are sterilized in the usual manner by boiling, and the pan or other receptacle in which they are sterilized may be used as an instrument tray.

While the physician is sterilizing his hands by one of the reliable methods, the nurse may again thoroughly scrub the vulva and surrounding parts with soap and water followed by bichloride solution. The field should be kept in an aseptic condition by sterile or bichloride towels, so arranged that only the vulva is exposed.

The physician should now thoroughly disinfect the vaginal outlet by sponging or irrigation with a 1-per-cent. lysol solution. After this is done the catheter is passed and the physician again immerses his hands in bichloride solution before commencing the operation.

Should any lubricant be needed for the hands or instruments, the lysol solution will be sufficient, and is an antiseptic.

The same vigilance against contamination of the hands by any unsterilized object should be observed as during any surgical operation.

REPAIR OF LACERATIONS.

Lacerations of the Perineum.—At the conclusion of labor the perineum should be inspected, and, if laceration to any degree has occurred, it should be repaired. The instruments required will be a perineum needle, three or four hæmostatic forceps, scissors, and a curved surgeon's needle with an eye

which will carry catgut. The patient should be placed in the lithotomy position, and, after the vagina has been cleansed of blood and clots by a douche of sterile water, the upper portion of the vagina should be packed with sterile gauze to keep the field of operation free from blood. If sterile water and gauze are not to be had, the douche may be a 1-per-cent. lysol solution, and 5-per-cent. iodoform gauze may take the place of sterile gauze.

The sutures on the skin surface of the perineum should be of silk-worm gut and must be passed deeply into the tissues. The stitches in the median line are passed close to the rectum, but must not penetrate any of its coats. To avoid this it is necessary in deep lacerations to pass the index finger of the left hand into the rectum, and it should be protected by a rubber finger cot, to be removed as soon as this portion of the operation is completed, and the hands must be again disinfected before the operation is continued.

After the silk-worm sutures have been introduced, but before they are tied, the laceration of the vaginal mucous membrane extending up the posterior wall of the vagina should be closed by a continuous suture of catgut, and the skin sutures are then tied.

After the removal of the vaginal pack and the cleansing of the perineum of blood, the surface is dusted with aristol and covered by a sterile vulvar dressing.

The catheter should be used for four or five days, care being taken not to allow the urine in the catheter to contaminate the wound as the instru-

ment is withdrawn. Care must also be taken that the wound is not infected by fæcal matter, and the cleansing should always be from the perineum toward the sacrum.

Lacerations of the Cervix are usually only discovered after convalescence, although immediate repair has some advocates. On account of the rapid involution of the uterus after confinement, the sutures rapidly become slack, and do not hold the margins of the wound in apposition for more than twenty-four or forty-eight hours. On this account, and also because any operation upon the upper portion of the vaginal canal or the uterus after labor increases the danger of infection, the immediate repair of the cervix is not to be advised unless it is necessary to check severe hæmorrhage from the laceration. Whenever excessive hæmorrhage which cannot be attributed to imperfect contraction of the uterus occurs, a laceration involving the cervical blood-vessels should be suspected and sought for. Should it be found upon examination, the hæmorrhage should be controlled by closing the laceration with catgut sutures drawn very tightly. The first suture should be so passed through the tissues of the cervix as to encircle the bleeding point, and the remainder of the sutures passed in the usual manner for cervical lacerations. The same aseptic precautions are used as in repair of the perineum.

THE DOUCHE.

From the difference in the practice of physicians regarding the use of the douche, both before

and after confinement, it is well to consider the matter to some length, that its exact value and dangers may be more clearly defined, and a more uniform practice employed.

First it may be stated that puerperal infection is always caused by infection through the vaginal canal, and is uninfluenced by atmospheric conditions or the diet of the patient. The principal question regarding the use of the douche is whether puerperal sepsis is ever caused by auto-infection by means of the bacteria present in the vaginal canal.

While good authorities were about evenly divided on this question for the decade following the first investigations of Gönner in 1887, it has been shown during the last five years that the diverse results of the earlier investigators were due to errors in the technique in securing the vaginal secretions for the examination, and at the present time it is well settled that the vaginal secretions are free from germs which can produce septicæmia, unless the woman has gonorrhœa or has been recently examined.

This absence of germs is due to the bactericidal power of the vaginal secretions, which was proved by Krönig to be destructive to staphylococci and streptococci in from six to twenty hours. He therefore concluded that the vagina may be assumed to be free from germs if the woman has been untouched for a period of two or three days. Döderlein verified Krönig's experiments, and he attributes the germicidal power of the vaginal secretion to the acidity of the secretion.

Dr. J. Whitbridge Williams has conducted a

large number of experiments in the lying-in ward of the Johns Hopkins Hospital, the results of which he gave in detail in a paper read before the American Gynæcological Society in May, 1898.

In this series of experiments he has conclusively shown that the vaginal secretion of pregnant women does not contain the usual pyogenic cocci, and that the results of investigators who have found these organisms in a considerable percentage of their examinations were due to errors in the method of securing the vaginal secretion, by which the bacteria, which they afterward found, were carried into the vagina by the instruments used.

The present status of vaginal bacteriology cannot be better told than by Dr. Williams's conclusions:—

1. As the vagina does not contain pyogenic cocci, auto-infection by them is impossible; and when they are found in the puerperal uterus they have been introduced from without.

2. The gonococcus is occasionally found in the vaginal secretion, and during the puerperium may extend from the cervix into the uterus and tubes.

3. It is possible, but not yet demonstrated, in very rare instances, that the vagina may contain bacteria, which may give rise to sapræmia and putrefactive endometritis by auto-infection.

4. Death from puerperal infection is always due to infection from without, and is usually due to neglect of aseptic precautions on the part of the physician or nurse.

Assuming that these conclusions are correct, it

may be seen that the antepartum douche is entirely unnecessary, and that during its use bacteria may be carried into the vaginal canal by the tube. Krönig asserts that the douche favors sepsis in this manner and also by lessening the antiseptic power of the vaginal secretion.

It is also plain that if the vaginal canal is free from germs at the commencement of labor, and if the examinations have been conducted with aseptic precautions, that the post-partum douche is entirely unnecessary.

Should there be any doubt regarding the perfection of the technique, a douche of 1-per-cent. lysol solution should be used after the completion of labor. This should be the last used during the puerperium unless septic symptoms develop. Should the vaginal discharge be offensive after four or five days, the douche may be used as a sanitary measure. Usually this odor is due to the decomposition of the discharges after they have reached the vaginal outlet, and frequent cleansing of the vulva by some mild antiseptic will be sufficient to prevent its occurrence.

The intra-uterine douche may be necessary in those septic cases which arise from infection of portions of placenta, blood-clots, or retained lochia from a retroflexion sufficient to obstruct the outflow from the uterus.

Whenever the intra-uterine douche is required, it should be used by the physician. It should be preceded by a careful cleansing of the external genitals with soap and water and bichloride solution 1 to 2000, and a vaginal douche of 1-per-cent. solution of lysol, or potassium permanganate solution 1 to

5000. Very little can be done in the way of disinfecting the uterine tissue by the douche, but the solution washes away the accumulated *débris* and bacteria, and so prevents the absorption of ptomaines. It is doubtful if any antiseptic solution in the strength in which it can be used in the uterine cavity has any advantage over sterile water or sterile salt solution.

The douche bag to be used for the intra-uterine douche should be sterilized by boiling unless it is a new one, in which case it may be filled with 1 to 1000 bichloride solution for not less than half an hour. The cut off should be slipped down to the end of the piping and closed so that the piping may be disinfected as well as the bag itself.

The tube to be used should have an outflow to insure a free escape for the irrigating fluid.

After these preparations have been made and a douche pan placed under the hips of the patient the physician disinfects his hands in the usual manner, takes the intra-uterine tube from the pan in which it has been boiled, and holds it in such a manner that the nurse may connect it with the piping of the douche bag without allowing her hands to come in contact with the tube.

One or two fingers of the right hand should then be passed into the vagina to locate the external os, and under their guidance the tube is passed into the uterus.

AFTER-CARE OF THE PATIENT.

The patient should be cautioned against removing the vulvar pad or touching the genitals with her hands. Every time it is necessary for the nurse

to change the vulvar pad or otherwise touch the patient the hands should be sterilized. The vulvar dressings should be sterilized by steam for the first five or six days, after which freshly laundered napkins may be used.

Sterilization of the vulvar dressings by baking in an oven is not sufficient. It is as easy to sterilize them by steam in an improvised sterilizer, and steam is much more effective than dry heat.

The pads should be changed as frequently as they become saturated, and the vulva should be bathed frequently by a 1-per-cent. solution of lysol or 1 to 5000 bichloride solution.

PUERPERAL INFECTION.

The essential condition in any case of puerperal fever is wound infection. The atrium may be in lacerations of the perineum, vagina, or cervix, or—as is more often the case—at the placental site.

The form of infection may be either sapræmic or septic.

Sapræmia occurs as a result of the decomposition of portions of placental tissue or blood-clots which have become infected by saprophytes. These saprophytes are non-pyogenic and do not enter the blood, but the poisoning is due to toxins absorbed through the placental wound.

Septic Infection is caused by the entrance to the circulation, through some wound surface of the genital tract, of bacteria or their toxins. If only the toxins are absorbed, the infection is a *septic intoxi-*

cation, while if the germs also enter the blood the condition may be designated as *bacteræmia.*

The necessity of the differentiation of the various forms of infection will be apparent when the treatment is discussed.

Generally speaking, the germs which cause septic infection are of the pyogenic group, although infection may occur from the streptococcus erysipelatosis, the bacillus of diphtheria, or by the specific, but as yet undetermined, organism of scarlet fever.

Septic Intoxication is caused by the absorption by the blood of the toxins elaborated at the original point of infection, which is usually the placental site. Should the local lesion be surrounded by a zone of granulation tissue, the patient may be protected from the entrance into the blood of the bacteria. Infection may extend to the peritoneal cavity, setting up a peritonitis or septicæmia, either through the medium of the blood-vessels or lymphatics.

Bacteræmia is caused by the entrance into the circulation of bacteria as well as the toxins which are formed at the original source of infection. If the bacteria are taken into the blood directly from the local lesion, septicæmia is produced, but if the blood infection comes through an infected thrombus, which in its disintegration throws into the circulation fragments of the clot which are infected by bacteria, pyæmia is the result.

Often septicæmia and pyæmia are associated. Ideal conditions for the development of septic thrombi in the uterine sinuses are present in the puerperal uterus.

DIAGNOSIS OF THE FORM OF INFECTION.

While a diagnosis of the variety of infection is very desirable, both on account of the prognosis and the treatment to be employed, it is often impossible to determine, and often there is a combination of the various forms, a sapræmia furnishing an excellent culture field for the development of the pyogenic bacteria, or a localized infection, which at first produces only a septic intoxication, runs into a bacteræmia.

The practical value of the differentiation of the various forms of infection lies in the fact that sapræmia and septic intoxication are amenable to local treatment, while in bacteræmia the germs have passed beyond the reach of local measures, and no radical operation should be undertaken.

Puerperal Sapræmia usually develops symptoms within three or four days of the date of confinement, and is usually attended by a chill and marked elevation of temperature. The most reliable diagnostic sign is the characteristic putrefactive odor which comes from the decomposition of flesh or blood. This odor is a positive sign of sapræmia, but the same error of technique which allowed the saprophytes to enter the uterus may have carried pyogenic cocci also, and thus have set up a mixed infection.

Septic Intoxication gives nearly the same initial symptoms as does septicæmia, by which it is frequently followed. After a period varying from two to five days the patient has a marked chill or chilly sensations, followed by a temperature of 101° to

104° F. and the usual symptoms incident to a sharp febrile reaction. There may be pain and tenderness over the uterus, but there is not general abdominal pain or tenderness. Sometimes the infection occurs from perineal or vaginal lacerations. The lochia are usually diminished in amount, but the vaginal discharge may have no offensive odor. Often the worst cases of septic infection are not accompanied by odor of the discharge, and, when it is marked, it shows a concurrent sapræmia.

Should the localized infection at the placental site remain unchecked, either by the granulation tissue barrier which is often thrown about it or by the local treatment employed by the physician, the infection extends more deeply into the uterine tissue, causing a thrombosis of the uterine sinuses, which may be the starting point of pyæmia, or the bacteria may gain entrance to the circulation directly through the blood-stream derived from the uterus, or by a septic peritonitis from extension of the disease through the uterine tissues.

Septicæmia usually develops symptoms within the first three or five days, with the same symptoms as septic intoxication. Should the case be of the latter variety, it will often yield promptly to local treatment, while septicæmia is progressive in its nature, as the bacteria which have gained entrance to the blood multiply there and the infection thus deepens.

Pyæmia is usually later in its development than the other forms, although it may be preceded by any of the other forms of septic infection, and the onset of the disease may be masked. It is charac-

terized by its recurring chills and sweats, irregular temperature, and later by secondary abscesses.

TREATMENT OF PUERPERAL INFECTION.

This may be briefly outlined by the broad statement that cases of sapræmia and septic intoxication should be treated by removal and disinfection of the original depot of infection, while all cases characterized by bacteræmia should be treated locally only so far as the absorption of toxins from the original seat of infection may be reduced to the minimum. The bacteria have already entered the blood in such numbers and multiply with such rapidity that local treatment is of little avail, and should not be persisted in if it exhausts the patient.

Sapræmia should always be treated by removal of the putrefying mass and disinfection of the uterine canal. Whenever the discharge has the characteristic putrefactive odor, no time should be lost in curettage of the uterus.

Extreme care must be exercised in all these cases that the curette does not penetrate the softened uterine tissue and enter the peritoneal cavity. A dull or wire curette is to be preferred to a sharp one, and its use requires fine tactile sense on the part of the operator.

The curettement is performed in the same manner as in gynæcological practice, and is followed by an intra-uterine douche of sterile water or 1-per-cent. lysol solution. The uterine cavity is then dried by sterile cotton wrapped on a uterine sound and disinfected as much as possible by the application,

on a cotton-wrapped sound, of a mixture of equal parts of tincture of iodine and 95-per-cent. carbolic acid. The cavity is then packed with 5-per-cent. iodoform gauze, to be removed the following day.

Should the infection be sapræmic alone, this procedure will be followed by a prompt cessation of symptoms, while, if it be a mixed infection, an excellent culture ground for the pyogenic organisms has been removed. The microscope may reveal the presence or absence of a mixed infection, but it is of little importance. If the odor of the discharges indicate the existence of sapræmia, the treatment should be a thorough removal of the retained portions of placenta or blood-clot.

Septic Intoxication can rarely be distinguished at the outset from septicæmia. Whenever a rise of temperature exceeding 101° F. occurs during the first week of the puerperium, septic infection should be suspected. Should the odor of the discharge be not suggestive of sapræmia, the continuance or increase of this temperature will justify a diagnosis of septic infection, unless the fever can be explained by some intercurrent affection.

The diagnosis between septic intoxication and septicæmia can rarely be made at this early period, but the treatment should be toward the disinfection of the infected wound surface.

Lacerations of the perineum, vagina, or cervix should be inspected, and, if they show signs of necrosis or infection, they should be disinfected by prolonged use of bichloride solution 1 to 2000, applied by means of a sterile gauze sponge saturated with the solution and held against the diseased sur-

face. Should a superficial necrosis be found, the bichloride solution will be ineffective, and the infected tissue may be treated by 95-per-cent. carbolic acid, followed by absolute alcohol. Should the infection arise from the placental wound, the intrauterine douche should be used every three or four hours. Some mild antiseptic solution may be used, although any antiseptic which can be safely employed in the uterine cavity immediately after delivery can have little germicidal power, and certainly cannot reach the germs which are below the tissue surface. The use of the douche is principally mechanical, by washing away the accumulated pus, with its contained bacteria and their toxins.

Constant Douching of the uterine cavity was introduced by Schücking, and used with success by Manseau. It is carried out by siphonage of sterilized water from a receptacle placed above the bed, through a rubber tubing and elastic catheter into the uterus. The catheter passes through a cervical speculum, which is fastened into the cervical canal by a silk-worm gut suture. This is a very rational procedure, but will not be often used unless it may be in hospital practice.

Curettage, in the absence of retained fragments of placenta or other products of conception, should not be performed. It breaks down the granulation tissue barriers which are being thrown about the infected tissue, and opens up new avenues for the bacteria to enter the circulation, often changing a septic intoxication into septicæmia.

Disinfection by means of carbolic acid and tincture of iodine should not be used, as it destroys only

a part of the infected tissue; but it also denudes the remainder of the uterine cavity of its mucous membrane, and prepares a large surface for infection by the bacilli which are sure to escape destruction by the attempted disinfection.

Hysterectomy for Puerperal Infection.—If the septic process progresses, notwithstanding the intrauterine douches, and if the enlargement and softening of the uterus, accompanied by uterine tenderness, shows a localized infection, we may consider the radical removal of the infected organ if we can exclude the presence of bacterial infection of the blood or a septic peritonitis. It is for the prevention of these complications that the hysterectomy should be done, and, if the infection has extended beyond the uterus and appendages, the removal of these organs will not stay the disease, but will lessen the power of the patient to resist it.

Unfortunately, the operation, to be successful, must be performed early, and in the early stages it is often impossible to determine whether the infection is purely local or whether bacteria are present in the blood.

Examinations of the blood are not as yet satisfactory in determining the existence of septicæmia, and examinations of the lochia do not determine whether the infection is local or general. Dr. H. J. Boldt considers that the following conditions demand radical operation, other less heroic measures being of no avail:—

1. If there are no conception products in the uterus, and the patient has fever with exacerbations;

chills; a small and frequent pulse, from 120 to 140 or more; if careful observation should show that the infection comes from the uterus alone; if there is no evidence of peritonitis, the uterus being enlarged and relaxed in its consistence, the parametria free; if streptococci are found in the uterus and not in the blood, hysterectomy is indicated.

2. If there are decomposition products in the uterus (sapræmia) which cannot be removed satisfactorily *per vaginam*, or if on doing a Cæsarian section the uterus is found septic, an abdominal hysterectomy is indicated.

3. Abdominal section with drainage is indicated in diffuse septic peritonitis when there is no evidence of an exudate in the *cul-de-sac* of Douglas. The adnexa are to be left undisturbed, unless there are positive indications to do otherwise.

Doubtless the indications for radical operation are as clearly defined by Dr. Boldt as can be done at the present time, but the difficulties of an exact interpretation of symptoms are so great that it will often be found that the uterus has been unnecessarily removed or that the disease has extended beyond the uterus and its adnexa, and that the operation has been futile.

When a hysterectomy is done for septic infection, the vaginal route should usually be selected.

Septicæmia and Pyæmia should be treated after the manner advised for these conditions following surgical operations. In addition to supporting treatment, such local disinfection as is not exhausting to the patient should be used. This should consist in

frequent vaginal douches with a 1-per-cent. lysol or 1 to 8000 potassium permanganate solution, and the intra-uterine douche once or twice daily. Should any localized abscesses appear, they should be drained and irrigated as soon as the presence of pus can be determined.

Antistreptococcic Serum.—For several years antistreptococcic serum has been used by many physicians for the cure of puerperal infection, with only doubtful results. As soon as the first positive reports reached the medical public, the newly discovered remedy was used in every variety of infection and reports of success or failure were of little value. Later, its scientific employment only in those cases in which the microscope shows streptococci in the lochia are of more value, and at the present time the general opinion of the profession at large is that, as a therapeutic measure in puerperal sepsis, the use of the serum is of very little value.

In some cases of purely streptococcic infection it has seemed to be curative, but the greater part of the cases of puerperal sepsis are due to mixed infection by streptococci, staphylococci, bacillus coli communis, etc.

Even in the cases of purely streptococcic infection the varieties of streptococci which may be the infecting agent are so many that the antitoxin is of uncertain value.

A fall in the temperature often follows its use, but this is not necessarily a good omen, and is considered by many observers to be due to the depressant action of the serum.

When used it must be early in the disease, and

may be administered hypodermically in 10-cubic-centimeter doses twice daily until from 40 to 60 cubic centimeters have been used. If improvement follows, the treatment may be continued with diminishing doses until the temperature becomes normal. Should no improvement follow its use by the time that 40 to 60 cubic centimeters have been injected, its use should be discontinued.

Intravascular Antisepsis.—Since a case diagnosed at Bellevue Hospital as puerperal septicæmia from streptococcic infection was recently reported as cured by the intravascular injection of formalin solution, much interest has been excited over the possibility of successfully treating all forms of bacteræmia by the injection of antiseptics into the veins. The cases which have been treated after this method with the exception of the first reported have not been encouraging.

The difficulty which has been mentioned—namely, of making a positive diagnosis between septic intoxication and septicæmia in the early stages of the infection—renders it possible that the case may have been one of septic intoxication.

The most that can be said of this treatment at the present time is that the experience in New York shows that the intravenous injection of suitable antiseptic solutions is not so dangerous as to render their use prohibitive.

In the London *Lancet* of January 10, 1903, Dr. J. M. Fortesque-Brickdale gives a review of the subject, with a summary of experiments, made at the Jenner Institute of Preventive Medicine.

Rabbits were used as the subjects of the experi-

ments, and the attempt was made to determine how far the injection of various substances into the circulation was capable of counteracting the effects of bacteria or bacterial poisons previously introduced. From these experiments the following conclusions are drawn:—

"That rabbits injected daily with non-toxic doses of oxycyanide of mercury, formic aldehyde, chinosol, protargol, or taurocholate of sodium are not thereby protected from the usual effects of a previous inoculation of virulent anthrax; and that chinosol and formic aldehyde in large doses so depress rabbits infected with the pneumococcus that they die sooner than the untreated animal."

While a positive opinion of the merits of intravenous antisepsis should be reserved until the results of its further use are observed, it cannot be said to have been reasonably established that the case in which recovery ensued would have proved fatal under other treatment.

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